POWER PLANT ENGINEERING

GENERATION - TRANSMISSION - DISTRIBUTION - UTILIZATION

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SUN MOTORS

IN THE FINAL ANALYSIS, of course, all motors are sun motors. All engines, all mechanisms used for the production of power use energy that originally came from the sun. Usually, however, when we speak of a sun motor we have in mind a device which operates directly by the action of sun light. Many attempts to construct such devices have been made and various schemes have been tried, concave mirrors have been focused on steam boilers, thermocouples have been arranged to convert the sun's heat into electricity, photochemical reactions have been experimented with, all with varying degrees of small success, but none of them of sufficient promise to warrant experimentation on a commercial scale.

The little sun motor shown here is perhaps little more efficient than its predecessors but it is interesting because it operates upon principles quite different from those heretofore used. It consists of an ordinary direct current motor operating directly on current supplied by a new photoelectric cell recently developed in the General Electric Research laboratories in Schenectady.

The motor is a tiny affair, rated at only four ten millionths of a horsepower. In direct sunlight it operates at about 400 r.p.m. but even the light of a 75 watt incandescent lamp at a distance of eight inches runs the motor at good speed. The photocells are of the selenium type far more sensitive, however, than the usual type for commercial and experimental service.

It is not to be inferred that the development of this device is going to revolutionize the power industry and engineers of power plants will not have to worry about their jobs on its account. But it is an interesting scientific toy and who knows but that some day somebody will make a more efficient cell. With this cell some 20 sq. ft. of surface is necessary to produce one watt.

Though our fuel supply is ample for a long time to come and though no one in this nor the succeeding generations need worry about it, it will not last forever and the time will come when it will be necessary to look to another source of supply for our power. Direct sunshine offers one possibility. If all the energy of the sun's rays could be converted into electricity, the sunshine falling on two counties in Texas could supply the power for the entire United States, continuously.

However, as we stated before it will be a long time before sun power becomes a practical reality so in the meantime we will continue to present information on the operation of present day power plants. We haven't space to discuss all the articles in this issue but we do want to call particular attention to the series of articles on Combustion Control which is starting in this issue. This series will present a clear discussion of the principles, operation and application of modern systems of combustion control which should be of value and interest to every power plant operator.

Today combustion control systems are available in many forms and are applicable not only in the large central station but in the small and medium size plant and low and medium pressure plant as well. In these articles we will describe in great detail how combustion control systems operate—how each piece of equipment works and how it is coordinated with other component of the system. The series will start with a consideration of the simplest types of damper regulators and then gradually proceed to the more complex and complete combustion control systems now in use.

Diesel power, too, is important, and, as a means of lowering power costs and improving service, one author in the issue suggests a Diesel Engine Users Association, patterned after the one in England.

Dr. C. W. Hewlett of the G. E. Research Laboratory with the new sun driven electric motor

WITH THE EDITORS

The President Follows Our Lead in National Power Policies

SINCE THE beginning of the century, Power Plant Engineering has championed more efficient generation, distribution and utilization of power. As the utility systems grew and the advantages of electricity became known, it was apparent that to serve the nation as a whole to the best advantage the utilities and industries would have to be drawn together in spite of their apparently divergent aims and needs.

Constantly increasing use of electricity has led to an insistent need for closer coöperation between industrial and utility plants, clearly set forth in an excellent presentation of the case by Guy B. Randall in an article (June 1, 1932, issue of Power Plant Engineering, p. 449), "The Pooling of Power—A Challenge to the Utilities."

Mr. Randall said: "Pooling of Power . . . comprehends the interconnection of every electric load in the country regardless of the nature of ownership . . . electric stations of all kinds would be interconnected . . . One could pour electricity in at one side of the pool while removing an equal quantity at the opposite side of the pool without having the input traverse the pool.

"For control purposes the pool would be divided into districts or blocks . . . The pool might be owned by the nation-at-large like our system of concrete highways (toll roads which were tried out a century ago did not work so well), by various companies like our railroads, or by one company like our telephone system. Regardless of ownership, the essential requisite of the pool idea is flexibility or fluidity."

The essentials as given above are elaborated in the original article and the advantages and difficulties covered in detail. In the December 1933 issue, page 508, George A. Orrok in an article, "The Economics of Power Generation" presents details of an arrangement of this kind now working in Belgium and incorporating an aggregate of 500,000 kw. under one load dispatcher.

Mr. Orrok's studies lead him to the following conclusion: "In this country the policy is commended because of the reduction of capital expenditure, very little consideration being given to efficiency because the utilities already lead the world in low fuel consumption as is shown by the reduction in the average use of fuel by the utilities from 3 lb. in 1920 to 1.51 lb. per kw-hr. in 1932. But much stress is being laid at the present time upon the larger amounts of by-product power available with the use of the higher steam pressures in new plants where process steam is the main consideration. The 'planned economy' of 1933 and the 'New Deal' all lead to coördination and combination as opposed to individual operation, and the act creating the Tennessee Valley Authority is based, among other things, on the coördination of power."

In advocating such an arrangement, President Roosevelt has given public recognition to the engineering policies as advocated by Power Plant Engineering over a peroid of many years. The ownership of such common carrier transmission lines involves grave questions of a political nature but the economic and sociological needs are so fundamental that interference with the final accomplishment should not be tolerated.

The nation at large demands not only a transmission system obligated to supply power as cheaply as is economically sound to those who have use for it and to purchase at reasonable rates surplus power from those willing to supply it, but the extension of such transmission facilities to parts of the country which at present might not justify such extensions economically. Such plans we believe can best be consummated by utilizing such private power companies as are now in the field or may enter it, working under the central authority of a suitable Federal commission with possibly Federal financial aid to extend transmission facilities. Such an arrangement would expedite consideration of the plan and should involve a minimum of political interference yet take advantage of the experience and facilities of private power companies in this work.

Regardless of real or fancied wrongs which have ensued from holding companies, the electrical development of this country has been due to the unaided and untiring efforts of the operating electrical utility companies over a period of fifty years. It is possible for a government to penalize without conscience those companies for their foresight, initiative and perseverance and to rob those who have invested in good faith of the fruits of two generations of labor and development but, regardless of the moral issue involved, it cannot afford to disregard the experience and honest efforts that these companies could build into any national power development.

Two most important results can be accomplished by development of the national pool of power: Operation of generating plants to best advantage, so that all hydraulic power which can economically be developed will be utilized, and only so much fuel-driven plant as is needed will be operated, loaded to point of good efficiency while in operation. Decentralization of industry so that great centers of manufacturing will not be further congested and factories can be so located that workers can live in better surroundings, with air, light and land for partial subsistence gardens. These results, also the rendering of rural life fuller and more efficient, are essential reasons why Power Plant Engineering has advocated such a national power policy. But this clearly does not necessitate or imply government ownership and operation of generating plants or transmission systems either as a competitive threat or a social policy.

Colgate-Palmolive-Peet Co.

Power and Steam Provided by New 425 lb. Plant with One Boiler and Turbine. Old Engine Generators Kept as Standby

By GOSTA ANBRO

Colgate-Palmolive-Peet Co., Jersey City, N. J.

EARLY LAST YEAR the Colgate-Palmolive-Peet Co. decided to shift some production from other plants to their Jeffersonville, Ind., plant, making it necessary to provide additional power and steam generating capacity. The old power plant generated steam at two pressures: 150 lb. ga. steam for process work and power plant auxiliaries; 125 lb. ga. steam for process work, engine generators and minor steam drives around the plant. All steam drives and engines exhausted at 5 lb. ga., the exhaust being used for process work, feed water heating and building heating.

When the plant was built, this layout gave a good average heat balance with a slight excess of exhaust in the summer and some deficiency in the winter. Later developments in production methods have resulted in considerable waste of exhaust steam all year round.

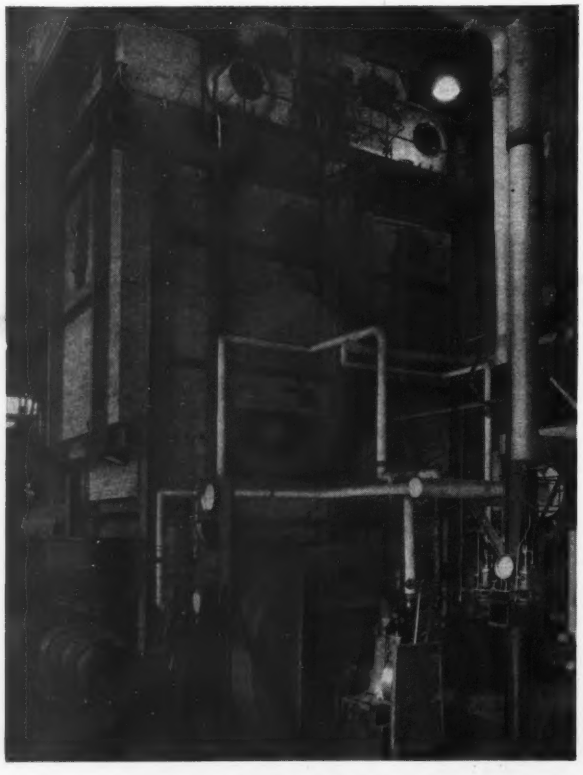


Fig. 1. The new boiler utilizes the height of the boiler room to the fullest extent

In considering additional equipment it was found that the exhaust waste could be eliminated if power were generated with an admission pressure of 200 to 250 lb. However, it is probable that in the near future the demand for power will increase without corresponding increase in process steam demand. To provide for this it was decided to raise the steam pressure for the new equipment as high as practicable.

Limiting factors were the desire to retain chemical feed water treatment and avoid make-up evaporators and the fact that a plant of this size cannot afford highly trained operators. The pressure was set at about 400 lb. at which pressure it became possible to generate nearly all power, needed at present, from the process steam used at 125 lb. It was found that this process pressure could be lowered to 100 lb. without detriment and to increase the available power sufficiently to take care of present requirements as well as the additional ones planned for the immediate future.

New Turbine

In view of this it was decided to install a straight back pressure turbine generator, exhausting at 100 lb. ga. and a boiler built for 425 lb. ga. pressure. The superheat was chosen so as to leave 50 to 75 deg. F. superheat in the turbine exhaust. The capacity of the generator was to be 500 kw. and that of the boiler 30,000 to 35,000 lb. per hr.

No spare high pressure equipment will be installed at present since it is felt that old equipment provides sufficient spare capacity in case of a breakdown on the high pressure units. Installation of additional high pressure equipment will depend on progressive obsollescence of old equipment and future demand for power and steam.

In the old engine room ample space was available for a new turbine generator but in the boiler room, space was a problem. After various trial designs it was found that a bent tube boiler, with a setting entirely satisfactory for chain grate firing could be installed in the space available in the old boiler room.

Extends Power Facilities

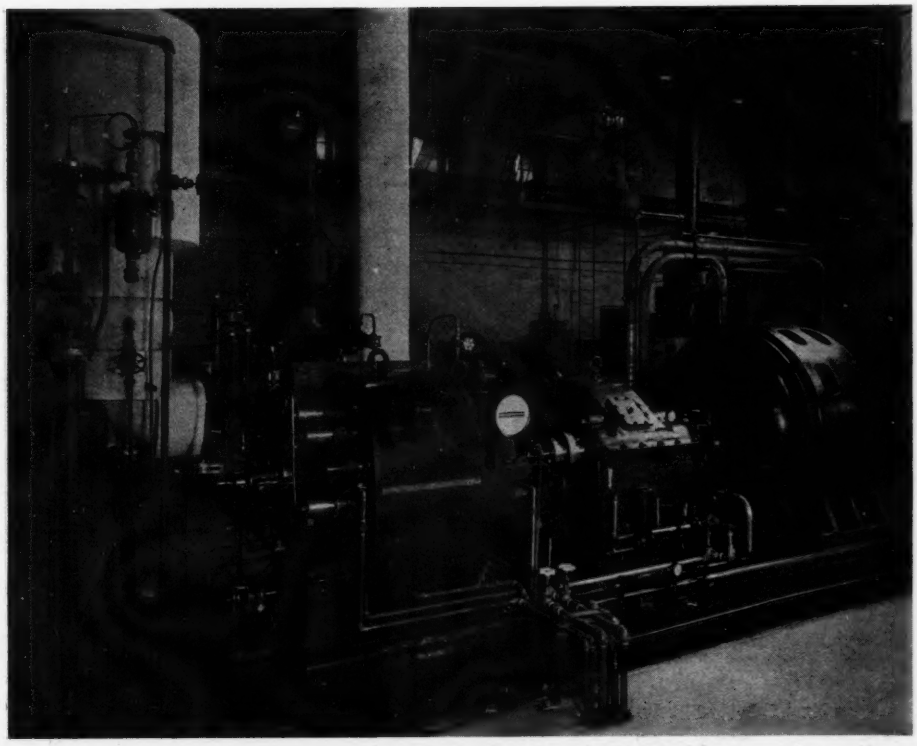


Fig. 2. The main generating unit is a geared turbo-generator rated at 500 kw.

Powdered coal was considered but, to get a satisfactory installation, it would be necessary to build a new extension to the boiler room and the slight gain in efficiency, to be expected with powdered coal, did not justify the additional expenditure for a building extension.

Since the flue gas temperature at the boiler exit is necessarily high with 400 lb. pressure, it was decided to add an economizer to recover some of the waste heat. The exit gas temperature was fixed at about 400 deg. F. In view of the fact that the gas would be discharged into a stack common with the old boilers operating on natural draft, it was considered inadvisable to go lower than this without materially reducing the draft on the old boilers. Water cooling was decided on to protect arch and side walls against the erosion and fluxing experienced with Indiana and western Kentucky coals.

New Boiler

The general arrangement of the new boiler unit is shown by the drawing, Fig. 3, while the photograph, Fig. 1, testifies that the available headroom has been utilized to the limit. Incidentally, the large fan in the foreground is for one of the old boilers as the fan for the new unit is the high speed unit of less imposing dimensions visible to the right.

Normally the new boiler will operate continuously at design capacity. Steam not taken by the new generator turbine will spill over into the 100 lb. main through a desuperheater, the flow being controlled by a pilot operated relief valve. The boiler safety valves are set to blow at 415 lb. ga., the relief valve starts to open at 395 lb. at the superheater outlet. The desuperheater is of the heat exchanger type located in the lower boiler drum.

In connection with this installation it was decided to operate all the old boilers at 150 lb. pressure and supply the 100 lb. steam through a reducing valve. The purpose of this was twofold: To improve circulation in some of the old boilers that suffered cracked headers frequently when operating at 125 lb. pressure and to utilize the old boilers somewhat in the manner of a steam accumulator.

The boilers are cross drum, 12 tubes high, with one return circulator from the top of each header to the drum. At low pressures, and consequently large specific volume of steam, the one circulator is insufficient and return circulation takes place in one or more of the inclined tubes below. A decrease in steam consumption will reverse the circulation and the resulting expansion and contraction of the tubes is sufficient to cause cracking of the cast iron headers.

The steam accumulator effect referred to is ob-

tained when there is a sudden increase in consumption of 100 lb. steam. The reducing valve opens up so that the pressure in the boilers drops below 150 lb. and some of the water in the boilers flashes into steam. Permitting a pressure drop of about 10 lb. in the boilers has helped to eliminate pressure fluctuation in the 100 lb. lines which before this arrangement were quite serious.

The general appearance of the new turbine generator is shown by the headpiece. It is a geared 500 kw. machine, 4650 to 1200 r.p.m. The turbine is straight back pressure, 390 lb. ga. at the throttle, exhausting against 100 lb. This unit replaces two old engine generators exhausting at 5 lb. ga. Any deficiency of 5 lb. steam, due to shutting down these engines, will be supplied through a reducing valve from the 100 lb. main for some time to come. When needed in the future, an additional turbine generator will be installed working on an expansion range of 390 to 5 lb. with a bleeder at the 100 lb. stage. The old engine generators will be retained, for the time being, for spares and possibly for parallel operation with the present turbine generator.

List of Principal Power Plant Equipment
Colgate-Palmolive-Peet Co.

BOILER ROOM

Boiler—Combustion Engineering Co., bent tube, 4 drum, 4100 sq. ft. plus 380 sq. ft. water walls and arch. 425 lb. ga. pressure.

Stoker—Combustion Engineering Co., forced draft chain grate.

Economizer—Combustion Engineering Co., fin tube, header type, 1950 sq. ft.

Superheater—Superheater Co., 135 deg. F., superheat at 400 lb. ga. and 30,000 lb. per hr.

Desuperheater—Superheater Co., heat exchanger type in boiler drum, 15,000 lb. per hr. from 400 lb. ga., 585 deg. F. to 100 lb. 435 deg. F.

Feed Pumps—Allis-Chalmers Mfg. Co., 2—85 g.p.m., 1100 ft. head, 3550 r.p.m.

Forced Draft Fan—B. F. Sturtevant Co., 15,000 c.f.m., 3.25 in., 1385 r.p.m.

Induced Draft Fan—American Blower Corp., 25,000 c.f.m., 3 in., 1745 r.p.m.

Auxiliary Turbine Drives—Elliott Co., 1—45 hp. direct connected; 1—13 hp. geared; 1—19 hp. geared.

Deaerating Feedwater Heater—Elliot Co.

Soot Blowers and Gauge Column—Diamond Power Specialty Corp.

Feed Water Regulator, Relief Valve and Reducing Valves—Swartwout Co.

Boiler Meter and Draft Gauges—Bailey Meter Co.

TURBINE ROOM

Main Turbine and Reduction Gear—Terry Steam Turbine Co., 500 kw., 4650/1200 r.p.m., 390 lb., 580 deg. F. to 100 lb.

Generator—Allis-Chalmers Mfg. Co., 500 kw., 1200 r.p.m., 480 v., 3-phase, 60 cycles.

Switchboard and Voltage Regulator—Allis-Chalmers Mfg. Co.

Piping—Midwest Piping and Supply Co.

Valves—Edward Valve and Mfg. Co., Wm. Powell Co.

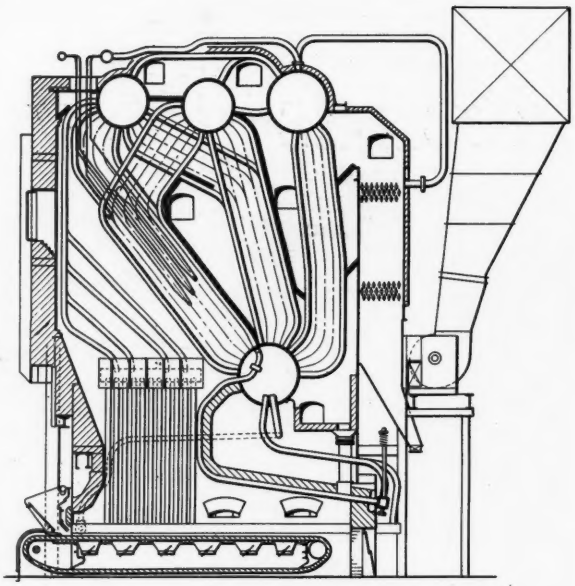


Fig. 3. Arrangement of the boiler and setting

All auxiliaries have steam turbine drives except one motor driven spare feed pump. These turbines are designed for 150 lb. admission and 5 lb. exhaust. Extra nozzles with hand valves are provided for operation with 100 lb. admission pressure.

The plant extension was designed and constructed by the company's own engineering force.

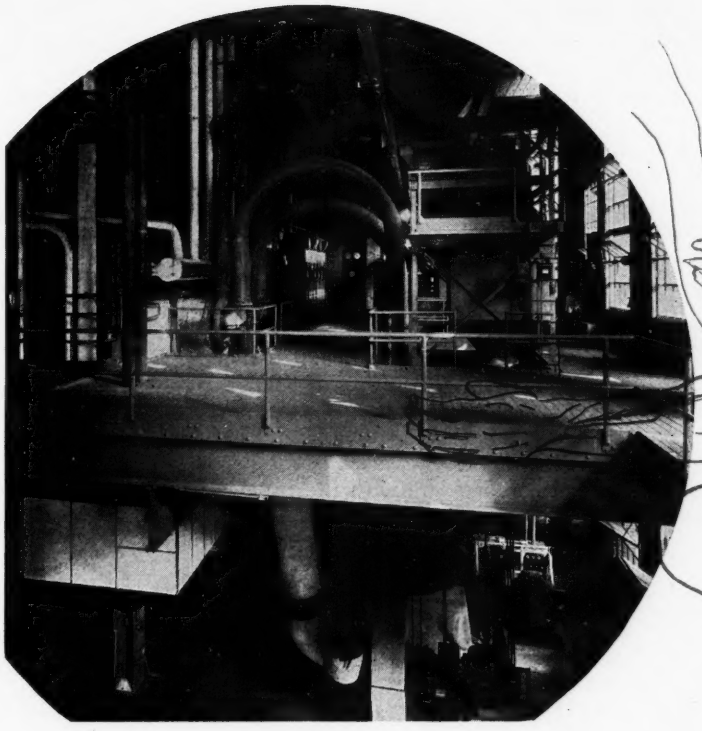
Managers

ON THIS SUBJECT, George P. Torrence, president of Link-Belt Co., states some facts in a recent issue of Link-Belt News that are worthy of careful attention in determining one's course of action, especially under present conditions.

Since man came to this planet, there have been managers, the head of the family, then head of the clan, then, as tribes built cities and combined to make nations, came kings and princes, later presidents, governors, mayors. Leaders are elected, appointed or seize power for from an hour to life, but managers are necessary where more than one individual is involved in any human activity, to lead when planning procedure and to put plans into effect.

Success of the activity is affected by the character of the management, whether foreman, superintendent, governor or president. We are striving for recovery and reëmployment. This recovery depends upon the soundness of plans and economic policies, upon the character of the management and upon the coöperation with the management of all concerned. Unfair criticism destroys coöperation. Unfaithful managers should be punished and incompetent ones should be removed, but management is a function inseparable from society and only by coöperating with its manager can any group or society as a whole progress and achieve recovery.

Recovery depends on sound plans and policies, competent management and coöperation with such management.



Combustion Control

Contrary to Popular Opinion Combustion Control Equipment Is Not Limited to Large High Pressure Installations. Combustion Control Systems Are Available for Small and Medium Size Industrial Boilers at a Price Which Can Be Economically Justified

WHEN THE AGE of steam power was ushered in during the early eighteenth century, the question of combustion and combustion control had already received serious consideration primarily as a means of eliminating objectionable smoke from the furnaces and fireplaces of the day. These problems must have been as old as fire itself, yet, the beginning of transition era between combustion as an art and combustion as a science may be placed at about 1685 when Delasme exhibited a smoke prevention device at the Fair of St. Germain.

Under the impetus of industrial demands the steam boiler and fuel firing equipment developed gradually into the large and efficient units we know today operating automatically under almost superhuman automatic control. In spite of the fact that early combustion engineers had a good practical understanding of the factors effecting the proper burning of coal, and that a number of stokers were invented early in the nineteenth century, actual progress in combustion practice was slow.

Power plants were confined to manufacturing and mining establishments interested in steam and power only parts of their major activity; metals and materials available were limited; and there was, perhaps, an over-emphasis on the development of engines. About 1880 prospects were somewhat improved by the establishment of central stations, introducing for the first time an element interested in the production of power as a major activity.

Development of transformers and motors soon widened the central station field but no radical developments in combustion equipment application occurred until after the introduction of the steam turbine about 1900. The adaptability of the turbine to large sizes soon made larger boilers imperative and forced the development of stokers to take care of the immense amounts of coal required. Really large and efficient boiler units are, however, a post war development, the result of concentrated electric loads and a belated realization that the boiler room is as important as the turbine room as far as the overall efficiency of the station is concerned.

Successful application of high pressures and temperatures the reheat and extraction cycle, automatic control, pulverized coal, air heaters, superheaters, stokers and boilers, in short, practically everything that makes the

within this last 15 yr. period. Theoretically these practices had been studied and advocated for years, yet sound theory had to await economic necessity before the development expense for practical application was undertaken.

This lag between theory and practice applies to

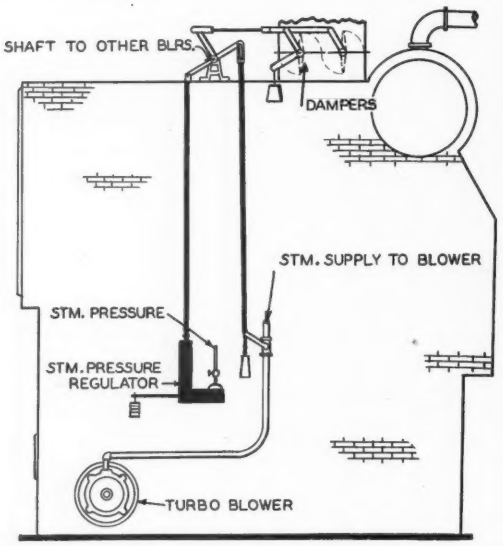


Fig. 1. Simple automatic control on a hand fired boiler. An increase in steam pressure causes the regulator piston to travel up, first closing the steam supply to the blower and then closing the damper

combustion control as well. Elementary and partial automatic controls have been available for over 100 yr., yet completely automatic combustion control systems made little practical progress until the size of boiler units increased to the point where direct control was no longer physically possible and centralized remote control systems became necessary. After this development period on large units, the adaptation of the improved equipment to medium and small sized units was rapid.

Another factor of importance in the development of automatic control was the decreasing water content of modern boilers, the combined result of higher ratings and the reduction in drum diameters of high pressure boilers to decrease the cost. Some modern boilers have only sufficient water capacity to run a couple of minutes at normal steaming capacities, thus giving feedwater control and regulation increased importance from the standpoint of boiler safety and stability, and making instantaneous control of combustion imperative.

At the same time, increasing fuel costs placed additional emphasis on efficiency and forced the installation of adequate instruments for the guidance of the operator. Instruments and remote control represent a large portion of the cost of a complete, automatic control system and with this start development, under the promise of reduced labor costs and higher efficiencies, was rapid.

In its broad aspect combustion control covers the entire steam generating unit from bunker to stack. Some of this equipment, the boiler itself and the baffling, the furnace, economizer, air heater, air ducts, breeching and stack play an important part in, and impose a definite limit on, the combustion process but are permanently installed and not readily susceptible to adjustment. On the other hand, stokers, pulverizers, feeders and burners, forced and induced draft fans and dampers are readily adjusted and it is upon the proper regulation of these parts that the efficiency of any given boiler unit depends.

In the final analysis these parts actually control combustion, but, as the term is generally understood today, "combustion control equipment" refers only to the mechanism by which the adjustment of the actual equipment is made. This control may be manual, partially automatic, or fully automatic, depending upon the needs of any particular plant.

It seems fair to assume that an automatic combustion control system could do no better than an alert operator using remote centralized control and guided by suitable instruments. Tests, however, show that automatic operation will give efficiencies ranging from 2 to 5 per cent higher than can be maintained by a full crew operating the plant manually with a full set of control instruments This is probably due to the fact that the automatic control is sensitive to small changes in pressure or flow, divides the load evenly between boiers and, perhaps most important, is constantly alert and ever vigilent. What the difference might be under lax routine operation is difficult to say but it might well be two or three times as much.

Maintenance of high efficiency is, of course, but one of the requirements of a successful automatic combustion control system. It must act as a boiler governor to maintain the desired steam pressure over the entire load range; it must provide safety through suitable interlocks on auxiliary drives and give the maximum protection in case of failure of component parts of the boiler unit or of the control itself; finally it must give low operating and maintenance costs for itself and for the furnace. The regulating devices must be sensitive, yet stable and free from hunting and capable of being coördinated with other parts of the system.

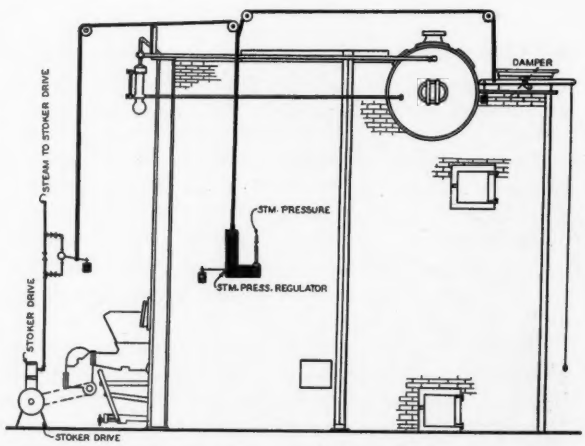


Fig. 2. The regulator action extended to include the control of fuel on a natural draft stoker

As a governor, the control must supply fuel and air so as to carry the steam load without an appreciable drop in steam pressure. These adjustments may be made without regard to either furnace or boiler effi-

ciency but, as a guardian of efficiency, the control must proportion the fuel and air so that the unavoidable heat and fuel losses are as low as possible. That is, the excess air must be held low so as to avoid excess heat losses in the flue gas, yet high enough to avoid incomplete combustion as indicated by smoke and combustibles in the flue gases or excessive combustible in the refuse.

As a watchman of maintenance expense, the control must regulate the furnace temperature, keeping it high enough to improve heat transfer and promote combustion, yet low enough to prevent slagging and excessive erosion of the furnace walls. This temperature can be controlled by means of the excess air, the higher the excess air, at a given rating, the lower the furnace temperature.

Such complicated functions appear to limit automatic combustion control systems to large units. This is not true, however, because control systems to meet the needs of all sized boilers from the largest to the smallest are now available involving not only fuel and air supplies but feedwater regulation, load control and CO_2, or, steam flow-air flow, corrections to compensate for air and fuel changes from average conditions for which the control is normally set. Having developed these complete control systems for large boilers, the manufacturers successfully set about adapting the systems for medium and small sized units at a price which would justify their application not only to new boilers but to old boilers as well.

THIS is the first of a series of articles on conbustion control explaining how the equipment works and showing where it may be applied to advantage. The series is a logical development of the January issue, a practical application of the fundamental instrument types such as pressure, temperature and flow measurements to the control of several related factors in order to give a desired and predetermined result. Automatic combustion control is no longer limited to the large plant. It is one definite and practical way for the small and medium sized industrial plant to cut costs and improve operation, the objective of all modernization plans.

With the exception of thermostatically controlled on and off systems used on some heating boilers, all automatic combustion control systems use the steam flow from the boiler as the primary impulse for the regulator. Some systems use, and actually meter, the steam flow while others use the pressure drop in the receiver or header as an indication of the flow, this pressure drop increasing approximately as the square of the steam flow.

Variations in steam flow or pressures are used to increase the air flow and fuel flow to the boiler as nearly at the same time and in the proper proportion as it is possible to do. Air flow is regulated by changing dampers or changing the speed of the fans and is metered or measured by the pressure loss over a certain section of the air duct or by the draft loss through a section of the boiler. Fuel is the most difficult to measure accurately due to irregularities in size, shape and condition. With coal, stokers or feeder speed is usually taken as an indication of the rate of feed with irregularities in metering the fuel and air ratio adjusted, either manually or automatically, through CO_2 or steam flow-air flow readings. With oil or gas, the problem is simplified considerably as more accurate fluid metering methods can be used and the ease of regulation gives perfect conditions for the application of automatic control.

Selection of the control systems used must depend, of course, primarily upon the factors available for control, the operating pressures and conditions and the auxiliary drives. At one extreme is the small hand fired, natural draft boiler on which only one automatic adjustment, the damper regulator, can be made. Due to the large water storage capacity a simple feed-

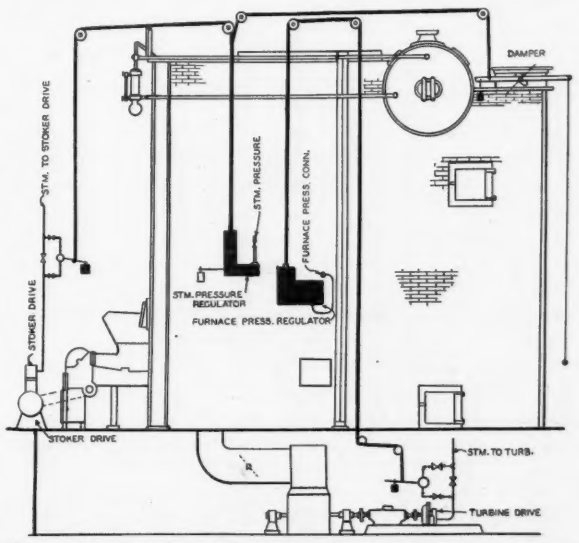


Fig. 3. Forced draft installations need a second regulator to assist in maintaining desired furnace conditions

water regulator operating from the water level is sufficient. At the other extreme is the large 600 to 800 lb. reheat boiler requiring fuel regulation, forced and induced draft control, steam temperature control and coördinated feedwater regulation.

This pressure range offers the most difficulties due to low water storage and the difference between the specific volume of steam and water. At high rates of steaming there is an appreciable swell due to the steam bubbles and in order to maintain a nearly constant weight of water in the boiler the water level must be maintained high at high ratings and low at low ratings. Many of the difficulties of feedwater control disappear at higher pressures due to the decreased specific volume of the steam bubbles, although, of course, the introduction of the higher pressure series boilers brings up new problems.

Figure 1 shows the simplest possible control system, a stack damper automatically regulated from the steam pressure. As the steam pressure drops, the damper is opened, increasing the draft and immediately increasing the rate of combustion or heat liberation. As the fuel burns out the fireman must replenish it either at the rate it is being burned out, or, if further load increases are expected, a little faster so as to build up the fuel bed to the point where the next increase can be carried.

With the common type of regulator, the steam pressure acts on a diaphragm which in turn operates a

small pilot valve to control the movement of a hydraulic piston operated by air, oil, water or steam pressure. This piston is connected by cable or linkage to the damper which it regulates.

The pressure regulator may adjust the damper of one boiler, or, if a number of boilers are operated in parallel, the dampers of all of them through a common shaft as shown by Fig. 1. Another arrangement

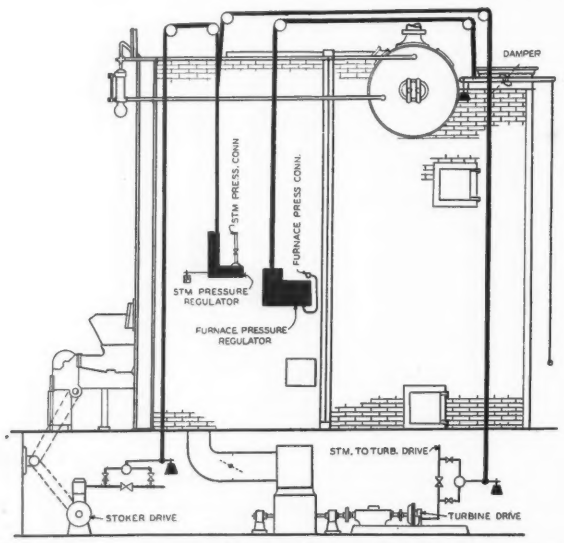


Fig. 4. A rearrangement of the regulators so that the pressure regulator controls the fuel feed and forced draft

possible with one regulator and a number of boilers is to have a breeching damper operated by the regulator and individual damper in each uptake operated manually. This facilitates the division of load between the boilers.

From the simple arrangement shown by Fig. 1 the next logical step is the automatic control of fuel by the same regulator. This is shown by Fig. 2 for a natural draft stoker with a steam engine drive. With oil and gas fuel the response of the fuel to load is rapid, but, with stokers, the fuel feed is slow and although the fireman is relieved of the labor of firing the coal it is still necessary for him to pay close attention to his fuel bed so it will be in a condition to handle large load changes when they occur. With the fuel bed in proper shape even sharp changes in the rate of combustion may be taken care of by the regulator through the control of the air supply.

For natural draft such an arrangement is sufficient but many of the small stokers use forced draft, which, unless the stoker includes an integral fan, necessitates an additional control element. It is conceivable that the function of the damper or steam pressure regulator could be extended to include the control of forced draft as well. Although this is done partially in some of the more extensive controls, the difficulty of coördinating three controls of different characteristics with each other makes another regulator advisable

For this purpose a draft or furnace pressure regulator can be added as shown by Fig. 3. This regulator controls the forced draft, either by means of a damper or by regulating the speed of the fan, so as to maintain the pressure in the furnace at, or, slightly below, atmospheric. As the uptake damper opens, the furnace pressure tends to decrease but the furnace pressure regulator increases the forced draft sufficient to compensate for the change and thus controls the rate of combustion as indicated by the position of the uptake damper.

The three variables, fuel feed, induced draft and forced draft are closely related and adjustments are practically simultaneous. Sometimes the steam pressure regulator controls the fuel feed and forced draft, leaving the furnace pressure regulator to take care of the uptake damper as shown by Fig. 4. The forced draft control may be either by damper as in Fig. 5, or by speed regulation of the fan in Figs. 3 and 4.

Inasmuch as the rate of combustion is controlled by the air flow through the fuel bed (provided coal is already on the grate) the steam pressure regulator is sometimes made to actuate only the forced draft, leaving the furnace pressure regulator to take care of the fuel feed and stack damper as in Fig. 5.

Many arrangements are possible, the most advantageous one to be used in any case depending upon the fuel to be burned, the design and type of the equipment to be controlled, the type and power of the regulator and the space and location available. For motor driven stokers and auxiliaries, the regulators normally control rheostats and although the regulators shown are all of the hydraulic type, electrical models are available for the same service.

These simple applications show elementary automatic control apparatus falling in the general classi-

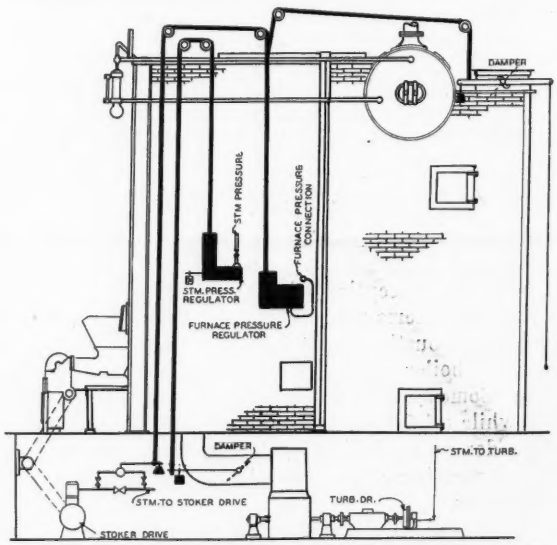


Fig. 5. Another modification in which the steam pressure regulator controls only the forced draft

fication of damper regulators as distinguished from complete, automatic combustion systems. Many of complete systems utilize these regulators as working parts but when used as shown they give but partial automatic control except under the most unusal load conditions, more closely approaching this condition with liquid and gaseous fuel than with coal. They do, however, relieve the fireman of a great deal of

(Continued on page 106)

Diesel Maintenance Cost Analysis

Not Only Should the Engineer Concern Himself with the Bookkeeping System But He Should See that Entries Are Properly Made. By Paul M. Thayer

PROBABLY the most discussed phase of Diesel engine operation is the question of cost of maintaining this type of equipment; figures are presented which show that the cost of maintaining a Diesel engine plant exceeds the cost of fuel, and also that the cost of maintenance is almost a negligible item. Figures supporting these extremes can be had from the records of actual operation of Diesel plants; the figures are correct, but the conclusions drawn from them are often erroneous in the extreme.

One instance that we know of illustrates a condition that too often exists in the records of power plant operation. In this particular case a starting air compressor was purchased and installed the year following the installation of the engine. The cost of this plant improvement amounted to over $1200 and it was charged on the books of the operating company as an item of Diesel engine repair, giving both the engine and the operator a black eye they did not deserve.

Spares

In every plant where continuity of service is at all important, and this means practically every Diesel plant in the country, it is highly desirable to have certain spare parts on hand ready for use in case of trouble. It is generally cheaper to order such parts in quantity lots, as by so doing there will be a very considerable saving in transportation charges, and a very probable reduction in first cost. How to charge these items that are ordered for stock is quite a problem; if it is left to the purchasing department, where such a department exists, the natural tendency will be to charge all these items as maintenance expense against the engine just as soon as the invoice is paid regardless of the fact that many, if not all the parts are put in the stock room and not on the engine.

It can readily be seen that such cost accounting as this will be very misleading to the management, and very detrimental to the reputation of the man in charge of the engine room. It is essential to have the bookkeeping accurately tell the story of what goes on in the engine room before it is possible to make an analysis of the maintenance of a Diesel engine that means anything.

The average Diesel engine operator looks upon the keeping of records as more or less of a nuisance and is inclined to slight this phase of his job whenever possible. This tendency on the part of Diesel engine operators has made the problem of getting accurate information about actual maintenance costs an exceedingly difficult one. This question of accurate records about engine performance is one that is of vital importance to everyone connected in any way with the Diesel engine industry, either as a manufacturer, a designer, a purchaser, or an operator.

A careful study of the record of repair parts used on any given design of Diesel engine will often show the designer points that are giving too much trouble and will indicate what should be done to correct the difficulty. It always is natural for any man responsible for the design of a piece of equipment to place the blame for any difficulty that might arise in the operation of it onto some other cause than a mistake on his own part. This is one reason why accurate figures on the history of each important part of any newly developed design is of such vital importance.

Study by Groups

Some years ago a careful study was made of the maintenance costs of an important group of Diesel engines operating under adverse conditions in the Southwest; these engines were of two different types but had the same general characteristics. In making this analysis all of the invoices covering material and repair parts were tabulated, these items were then grouped roughly according to the general classification to which they belonged, such as; air injection system, fuel pumps and valves, cylinder heads, cylinder liners, pistons, etc. These were again grouped according to the length the engines had been in service, and still again according to the load factor on the engines individually.

There was no consistency in the results because of the diverse conditions under which the different units operated and because of the fact that all items were charged as repairs as soon as they were received even though many of the larger items were obviously kept in stock for a long time after they were purchased. As would be expected, the major portion of the repairs were required for those items that were in direct contact with the heat of combustion; liners, heads, pistons and piston rings.

There were some rather surprising things brought to light, however. One of these was the fact that there

had been quite a lot of trouble with exhaust pipes, a place that one would naturally expect to be practically free from trouble. These particular exhaust pipes were water jacketed and were made of heavy cast iron, there was no question but that the trouble was entirely due to bad cooling water liming up the jackets preventing proper circulation. As one result of this analysis the designers decided to abandon this type of exhaust pipe altogether and make it from welded steel with asbestos lagging covered with canvass in place of the water jacket.

This new type of exhaust header and pipe has been in service for the past few years and there has been no recurrence of the old troubles. This new design of exhaust header was much cheaper to build, easier to ship and erect, gave the engine a trimmer appearance and made the unit much more accessible; but more important perhaps than all these items together, this change in design reduced this particular item of maintenance to practically zero.

Costs $1 per Hp. Yr.

Study of actual maintenance costs outlined above was carried out primarily to lay a basis for an accurate prediction of the probable cost of these items of a large Diesel engine plant which was under consideration at that time. So much had been said about the cost of keeping a Diesel engine plant in satisfactory operating condition that it was necessary to go into this phase of the problem in a thorough manner; tentative maintenance schedules were set up, with the probable life of each major item shown together with the cost of taking care of the necessary replacements when they would be required; everything that could be thought of to reduce this item of operating expense was considered and those which seemed the most reasonable were used.

The plant was built and placed in operation about seven years ago. Accurate records of the maintenance cost of this plant have been kept in detail ever since with the remarkable result that, even though the plant has been overloaded as much as twenty per cent at times, the cost of repair parts were well within the prediction, and has not amounted to as much as $1.00 per hp. per yr. In achieving this result there has been no attempt to get by in order to make a record, but every part that needed replacing has been installed before any serious trouble resulted. Such replacement of parts at the first sign of trouble will always result in an overall reduction in maintenance cost.

So far we have spoken exclusively about repair parts and the maintenance work of replacing them when necessary. There is still another side to this problem that should not be overlooked. That is the routine inspection of every part of the equipment. In making this routine inspection, records should be kept of every item that is subject to wear, such as the cylinder liners, crankshaft, main bearings, etc. A comparison of the amount of wear from one inspection to the next, together with the number of hours run and average load, will indicate clearly whether there is anything developing that will lead to future trouble if it is not taken care of at once.

If the figures on wear are plotted against time on cross section paper, points that may be in danger of developing future trouble will become self evident much more easily than if these same records are kept in numerical form only.

Advocates Diesel Engine Users' Association

There is no question but that the entire Diesel engine industry would be greatly benefited if those responsible for the design and construction of engines were in closer and more harmonious contact with the users of their engines, both owners and operators. One of the chief bones of contention between the various groups is this one of maintenance; and the reason for this is that no one really makes an effort to find out what a reasonable maintenance cost for any given plant should be, or why such costs get out of line, with such a cost, when things go wrong.

There is one real difficulty standing in the way of a general understanding of maintenance costs of Diesel engines and that is that there is no uniform method of keeping track of such items and no clearing house for compiling such data, studying it and disseminating it.

In order to do this effectively, the writer suggests that a Diesel Engine Users Association be organized for the purpose of compiling records of operation and maintenance of all Diesel engines in the country, the formulating of standard accounting methods for keeping records of operation, and generally aiding the owners and operators of Diesel engine plants to get better performance from their engines and more satisfactory returns on their investments. The Diesel Engine Manufacturers Association now in existence does not concern itself directly with matters of moment to the users of such engines from the user's standpoint.

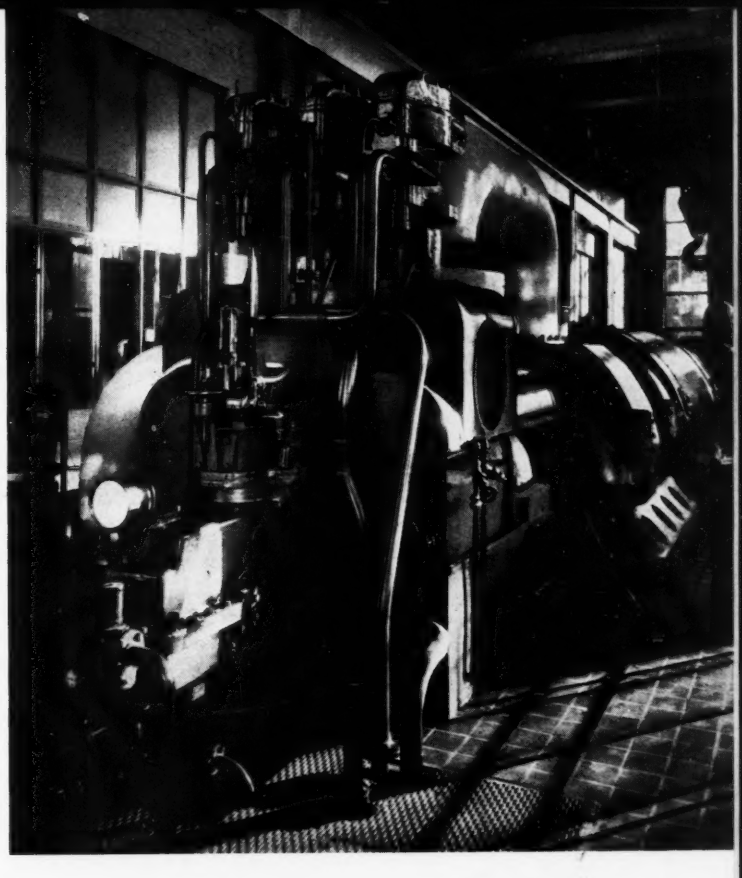
Weld Saves $475

Welding can be of great service in repair work and Oliver's Garage at New Underwood, S. D., recently proved this by successfully welding a broken crankshaft belonging to a 45 h.p., 3 cylinder Diesel engine. The price of a new shaft and bearings was $550. The old shaft was welded and machined at a total cost of $75 or a saving of $475.

In preparing the job, which was handled with a P & H-Hansen Arc Welder using from 250 to 300 amp., the shaft was blocked on a lathe to line up as nearly true as possible. The broken section was veed out with a cutting torch from one side to the center. A bead was then run through with the arc welder and the sides tackwelded sufficiently to allow the shaft to be turned over and the operation repeated on the other side. Now being strong enough to take out of the lathe, the shaft was built up a little at a time until the welded portion was larger than original size.

The shaft was then put back into the lathe with a press mounted over it and straightened to within 0.030 in. of true as recorded by the dial gauge. Following this, all main bearings were ground 0.050 in. undersize. With bearings rebabbitted and bored to fit the shaft, everything lined up and turned freely after being assembled. The engine, since run well over 100 hrs., is performing excellently.

Few single factors in the operation of turbines and other prime movers are of greater importance than that of lubrication. This article discusses the subject from a modern standpoint and outlines present practice. Many of the practices discussed have been drawn from statements by large operating companies, a fact which should be of interest to operating men as it will give him a basis for comparison with performance in his own plant



By GUSTAV A. GAFFERT

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Worcester, Massachusetts

Turbine Lubrication *and* Oil Purification

IN CONNECTION with the lubrication of prime movers, modern methods of installation, means of accomplishment, and operating data on typical installations are subjects which have not been given proper weight in technical literature. The trend in modern practice seems to be toward a uniform method of oil treatment. In the matter of installation some improved details of machinery arrangement are to be noted. Also, the ever present possibility of fire due to proximity of the turbine oil reservoir to high pressure steam pipes—as well as some actual fires—has reopened the whole question of remote location and its effects on the rest of the oiling system.

From a standpoint of design, the turbine manufacturer has taken the stand on practically all larger installations that he will prefer to supply not only the oil pump geared directly to the main turbine shaft and the auxiliary oil pump turbine but also the oil coolers and the oil piping connecting the various pumps, reservoir and bearings, since all of these items are intimately connected with turbine performance. The preferred arrangement of piping and auxiliaries is then settled between the manufacturer and the client or the latter's engineers. At once the question arises concerning the elevation of supply and return oil piping with reference to operating floor level. With small turbines, appearances may not be so important, but on larger installations, notably central stations, it is considered better practice to run both sets of piping under the main floor. The top of the turbine oil tank reservoir may then conveniently be made a part of the operating floor decking around the high pressure end. Final arrangements of all equipment as well as piping are subject to the approval of the manufacturer since he assumes responsibility for the proper lubrication of the prime mover.

Oil Pressure Must Be Maintained

A modern lubricating system for a large turbine includes a steam driven auxiliary oil pump operating in parallel with the regular geared unit. Should the supply oil pressure fall to a low value, a valve balanced normally by this pressure would allow high pressure steam to pass to this auxiliary oil pump turbine and restore operating pressure. With regard to location the auxiliary oil pump turbine can usually be conveniently located with the turbine head just above the floor plate near the high pressure end.

When the whole lubricating system is considered, a certain amount of latitude must be allowed in locating the various parts of the system. From an operat-

ing viewpoint, the oil coolers may be located anywhere underneath the main operating floor as long as the control valves are brought up to main floor level and readily accessible. Continuity of operation usually demands two oil coolers on large turbines, each capable of cooling the oil for the whole system. Such coolers are similar to heat exchangers and are usually water

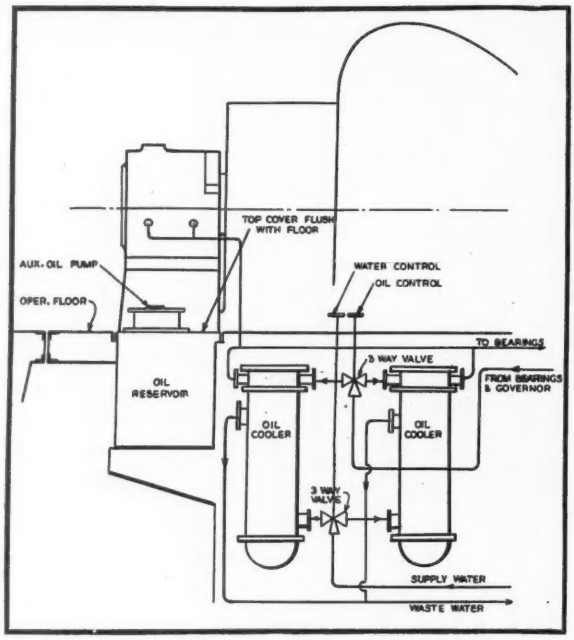


Fig. 1. Common arrangement of lubricating oil coolers

cooled by service water rather than by condensate, since the possibility of contamination of the latter is great unless special precautions are taken in packing or rolling the tubes. A popular arrangement of coolers is shown in Fig. 1. Vertical closed type coolers are used and supported alongside the turbine foundation. Also the turbine oil reservoir is located bracketed off the front end of the foundation with top flush with the floor. For convenience in operation, the operating valves on both the water and oil supply lines are brought up above operating floor level with extension stems. Three way valves are used so that it is impossible to close the valve completely and, further, a change over from one cooler to the other is quickly made in case of tube trouble, plugged water supply to one cooler, or fouled oil tubes as registered by the rising oil temperature on the discharge side of the cooler.

Checking Performance of the Lubricating Oil System

An oil pressure gage on the turbine gage board is very useful. Also, whereas gage board mounted indicating thermometers cannot be justified because of the number required, scale thermometers located at important check points are considered necessary. Temperature to the thrust and various main bearings on both the turbine and generator are important as well as return oil temperature and supply oil temperature at the cooler.

Purification of lubricating oil in a modern plant is recognized as being more economical than running an oil until its characteristics make it imperative to provide a new supply. A high grade oil is also a good investment and several good indices are available to indicate suitability of an oil. One of these is viscosity or resistance to flow under the shearing reaction of the forces in turbine bearings. A high viscosity usually results in high oil discharge temperatures and oxidation. The neutralization number of an oil, meaning the number of milligrams of potassium hydroxide necessary to neutralize the oxides contained in one gram of oil, indicates the condition of the oil and liability to form sludges. Some oils tend to absorb water more readily than others and form emulsions. Comparison with an emulsion standard will give an index of this characteristic. Also from chemical analysis the amount of carbon residue and sediment indicate at least its initial condition.

Removing Water From Oil

No oiling system is free of water due to bearing leakage. Due also to presence of air, oil will oxidize or combine with air chemically in time, and is the principal reason for not operating at too high a temperature. Oil will not only pick up water but will also absorb solids and in time will form a sludge. We have therefore two things to contend with in reconditioning an oil: the removal of water and soluble as well as insoluble impurities. In a modern plant, this can be handled effectively. A centrifuging machine will remove the heavier impurities which will collect in the pocket of the bowl of the centrifuge. Water can readily be separated due to the difference in specific gravity. In many cases this treatment is all that is necessary to maintain effective lubricating qualities. In this case the oil centrifuge can conveniently be located on the main operating floor and take oil from the bottom of the oil reservoir and discharge centrifuged oil back into the same tank.

When relatively large oil quantities are involved, such as required by central station turbines, a periodic settling and filtering will restore a charge of oil to a condition where it may again approach its initial state. It is customary to provide one or preferably two compartment batch filtration tanks for this purpose, each compartment having as a minimum storage capacity equal to that of the turbine reservoir. After draining oil to storage, impurities will settle and may be drawn off the bottom readily if there is a slight slope. To maintain efficient settling, the oil temperature must be high enough to maintain fluidity, requiring steam heated coils in the tanks. Oil is allowed to pass through cloth filters and finally passes to the filtered oil storage section of the tank. The physical layout of a system which is designed to provide continuous centrifuging and periodic batch filtration is shown in Fig. 2. With such a system it should be possible to accomplish transfer from one tank to another, centrifuge continuously, fill the turbine reservoir with clean oil or centrifuge the oil directly from a turbine and then put it into storage.

The usual location for batch filtration tanks is some corner of the turbine room basement so that gravity

drain can be used from the turbine oil reservoir, although the centrifuge is placed on the main operating floor level in many cases. It is apparent that the arrangement shown can be extended for additional units merely by additional piping or possibly a separate centrifuging machine for each unit, but using, however, common batch filtration tanks. Since the capacity of turbine oil reservoirs vary almost directly with the size of the unit and the number of bearings, it is well to provide tank capacity for the largest unit contemplated.

Operating Data on Large Turbines

Temperature of oil from the oil cooler varies from 95 deg. F. to 110 deg. F. but the return temperatures to the cooler from either bearings or the governor system does not exceed 140 deg. F. and the majority run under 130 deg. F. Higher temperatures accelerate oxidation. Most plants prefer to operate on a regular schedule of centrifuging—either a certain number of hours per day varying from six to eight or by-passing continuously five to ten per cent of the oil in flow and returning this oil directly back into service. Make up oil is also added at varying rates per month. The periods of operation between complete withdrawals of oil varies, but, since a heavily loaded turbine usually comes out of service once a year for an annual inspection, the oil is usually filtered annually. This period can in some cases be extended if samples of oil are withdrawn periodically and indicate no material change upon close visual examination. Settling must be allowed before a comparison is made. In the case of Diesel plants lubricating oil receives more severe service, in particular because of cylinder lubrication, and records for municipal plants show a period of 3000 to 5000 hr. between complete withdrawals and batch filtration. Continuous by-pass centrifuging is also employed in the latter plants.

When filling the oiling system with oil, it has proven wise to run this oil through a fine strainer before it reaches the turbine oil reservoir, and when a turbine is first started to check carefully oil temperatures throughout the system on the regular operating thermometers before loading the turbine. An operating convenience employed is the sight overflow, and may be located as shown in Fig. 2 to give the turbine operator a means of noting quickly whether or not the system is operating satisfactorily.

Fire Hazard

The question of fire hazard has come prominently into consideration of late; particularly because of two fires originating in central stations of importance. The problem is complicated by the fact that the governing system is also supplied with oil from the oil pump to operate the throttling admission valve through relay action. The solution of such difficulties suggest possible separation of the oil lubricating system and governing system, also the possibility of a non-inflammable fluid or remote location of some of the oil lubricating apparatus.

The location of the turbine oil reservoir directly in front of the high pressure end of the machine with supply and return piping is an obvious fire hazard. The type of piping and joints used in the past have been conducive to leakage. This is particularly true where cast-iron flanges have been used, and it has been suggested that a better choice of materials would be seamless copper piping or welded steel piping without joints, except possibly steel flanges at the connections to the oil pumps and oil coolers.

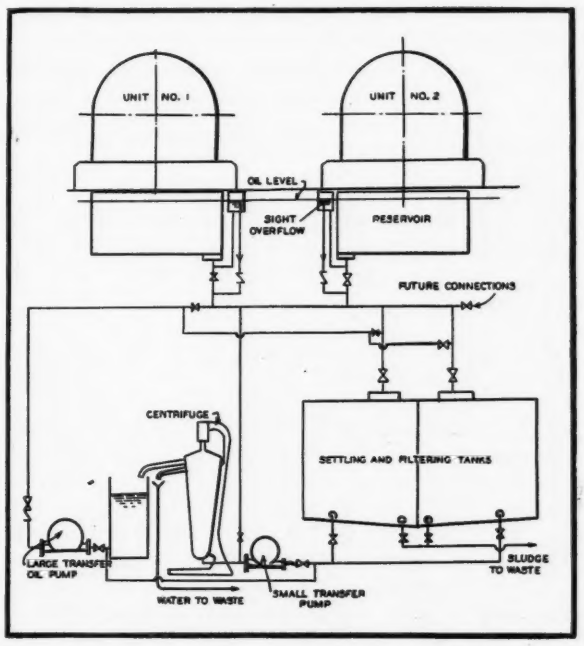


Fig. 2. Layout of system for continuous centrifuging and periodic batch filtering

In addition to a change in piping standards, a complete relocation of the turbine oil reservoir placing it in a separate basement room with the centrifuging and batch filtering equipment is a distinct advance. In this case the only real changes involved are the length of oil piping involved and the head against which the transfer pumps have to operate. Duplicate pumps should be installed to take the centrifuged oil from the basement to the bearings and other points of use, and ample pipe size allowed on the return lines.

The possibility of separating bearing lubrication and governor oil is also promising. A separate pump located on the main operating floor supplying non-inflammable fluid to the governor system would improve this situation. Diphenyloxide would be satisfactory, since it is a good lubricant, but it is inflammable. Research may provide us with a non-inflammable lubricant of a synthetic nature, and we may conclude that there are still beneficial changes to be made in oiling systems.

Transformer cooling by air blast at Chalon-sur-Saone is by 4950 cu. ft. air per min. at 4.33 in. water pressure for each 10,500-kv-a. transformer at 15,000 v. Fan motors are 4.4-hp., 3-phase, 220-v., at 2950 r.p.m. Air blast is applied to tubular radiators, with convection circulation, the fans being stopped and started by thermostatic control.

Predictable Performance of CENTRIFUGAL PUMPS

Affinity Relations, Dynamic Similarity and Specific Needs of Centrifugal Pump Impellers Useful for Predetermination of Pump Performance. By A. J. Stepanoff*

ALTHOUGH the theory of centrifugal pumps has made marked progress during the last few years, improvements in the design and performance were attained mostly in an experimental way. The predetermination of the head-capacity curves, and the selection of the leading dimensions of the pump, are based on previous experience.

Introduction of the conception of specific speed for pump classification provided a scientific basis for the systematization and evaluation of the accumulated experimental knowledge which enabled designers to interpolate between the existing types of pumps, and also indicated the way for the development of new types beyond the regions already well explored.

Predetermination of the performance of a pump at different speeds, or similar pumps of different sizes, is based on the use of "affinity laws" established first experimentally for hydraulic turbines. For the range of speeds and reduction factors used, these laws hold so well that often the acceptance tests of large pumps are made from a model test, the efficiency being stipulated as a multiplier of the efficiency of the model.

Uncertainty in efficiency is caused by the fact that the pump efficiency is affected by hydraulic losses which are only a small fraction of the pump input and are difficult to analyze. The term "affinity law" designates the following relationships between head, capacity, speed and size of the pump.

A. For the same pump if the speed is varied: (1) the capacity changes directly as the speed; (2) the head varies directly as the square of the speed for points of substantially the same efficiency. From these two it follows that the brake horsepower varies as the cube of the speed, since the pump efficiency is subject only to minor change for corresponding points.

B. For geometrically similar pumps operated at the same speed; (1) the capacity varies directly as the cube of the ratio of any linear dimension, for brevity called "reduction factor or multiplier"; (2) the head varies directly as the square of the factor; (3) the brake horsepower varies directly as the fifth power of the factor. If similar pumps are run at different speeds rules A and B are applied simultaneously.

C. For the same pump, if the impeller diameter is cut: (1) the capacity varies directly as the impeller diameter; (2) the head varies directly as the square of the diameter; (3) the power varies directly as the cube of the impeller diameter. This is true for small impeller cuts only. For larger cuts the head and capacity decrease faster than given by these rules.

The tabulation below shows the relationship between the diameter in per cent of original diameter calculated from the rules in this paragraph, and the approximate deviation from this rule shown by actual experience.

Calculated Impeller Dia. in Per Cent of Original Dia.	65	70	75	80	85	90	95
Required Dia. in Per Cent of Original Dia.	71	75	79	83	87	91.5	95.5

The "affinity laws" governing the variation of the head and capacity with the pump speed and size apply not only to the best efficiency point, but to any point on the head-capacity curve not affected by the excessive suction lift.

Specific Speed

Specific speed, n_s, is defined as speed in revolutions per minute at which an impeller geometrically similar to the one under consideration and reduced in size develops a head of 1 ft. and a capacity of 1 g.p.m. The formula for the calculation of the specific speed is:

$$n_s = n \sqrt{Q} \div H^{3/4}$$

where
n is the speed in r.p.m.
Q is capacity in g.p.m.
H is head in ft.

The following information about specific speed is important for the study and design of centrifugal pumps.

A. The physical meaning of specific speed as revolutions per minute to give one foot of head and one gallon per minute capacity has no application or interest to the designer. The number is used merely as a type characteristic for impellers geometrically similar. It can be shown that specific speed is only one form of criterion characterizing the operation of centrifugal pumps in the same manner as Reynolds' number does in the case of pipe flow.

B. As a type number specific speed is used to designate the operating characteristic for the best efficiency point only.

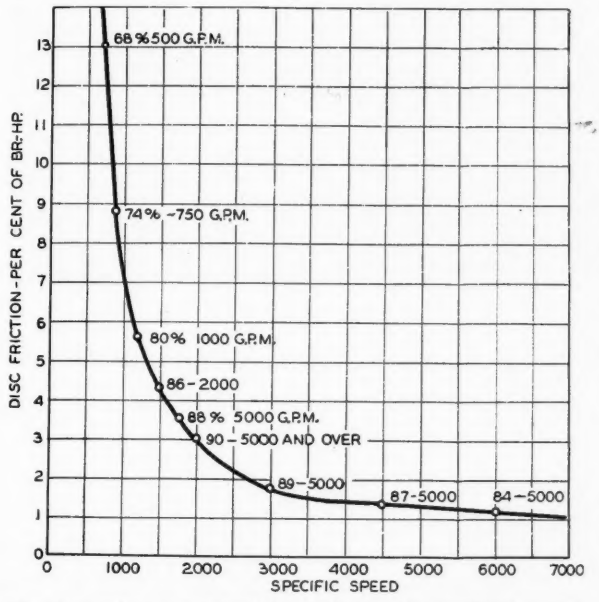
C. For any impeller the specific speed varies from zero to infinity for various points on the head-capacity

*Byron Jackson Co. From a paper presented before the A.S.M.E.

curve, being zero when the capacity is zero and infinity when the head is zero.

D. For similar impellers the specific speed is constant for different speeds and sizes.

E. If the same head and capacity requirements are met with pumps of different types, high specific speed pumps will run at a higher speed and be smaller in size, hence cheaper and requiring smaller high speed motors.



Disc friction loss as calculated for double suction centrifugal pumps

For the purpose of illustration, disc friction loss was computed for double suction pumps of different specific speeds and plotted on the attached figure as percentage of pump brake horsepower (not WHP) using actual impeller diameters and modern well established efficiencies attainable at various specific speeds. The efficiencies used and the sizes of pumps in gallons per minute for which these efficiencies were obtained, are given on figure for several points. It will be noticed that the rapid drop of pump efficiency with the decrease of specific speed below 1000, is mainly caused by the increase of the disc friction loss.

F. By cutting the impeller diameter the specific speed varies approximately in inverse ratio of the diameters.

The specific speed, as well as other constants important for the analysis of centrifugal pumps, such as unit head and unit capacity, may be derived by "dimensional analysis" which, applied to problems of similitude in hydraulics, has proven a useful tool in many instances; for example, from experience with water, conclusions may be drawn as to behavior of pumps when pumping liquids of different viscosities:

When pumping viscous oils, the "affinity laws" still hold if the flow remains in the turbulent state, which is mostly the case in practice. When pumping viscous oils, the drop in efficiency is smaller for pumps of higher speed, i.e., higher specific speed.

Similar relationships, giving the variation of losses in the centrifugal as a function of specific speed, head or capacity, may be established. These losses comprise, besides those defined by hydraulic efficiency, so-called external losses, such as disc friction, leakage and axial thrust, and these relationships may be called by analogy "affinity relations" for these losses.

In pumps of the same specific speed but of different size and operating at different speeds: (1) the disc friction horsepower varies directly as the pump output or water horsepower; (2) the leakage loss horsepower also varies as the water horsepower. Hence, if both are expressed in per cent of the water horsepower, both are constant.

In pumps of the same output (water horsepower), but of different size and running at different speed: (1) the disc friction horsepower varies inversely as the square of the specific speed and directly as the fifth power of factor C (from the equation for the velocity leaving the impeller $u_2 = C\sqrt{2_g H}$); (2) the leakage loss horsepower varies inversely as the factor K_v (from the equation for the radial velocity through the impeller eye $c_m = K_v \sqrt{2_g H}$).

In multi-stage pumps of the same capacity and total head, but of different number of stages, size and speed: (1) the disc friction horsepower varies inversely as the square of the specific speed and directly as the fifth power of C. For the same speed and assuming C to be constant, the disc friction horsepower varies inversely as 3/2 power of the number of stages, or inversely as the square of the specific speed; (2) the leakage loss through the wearing rings expressed in horsepower varies inversely as the factor K_v. If the speed is the same, the leakage horsepower varies inversely as square root of the number of stages, or inversely as the 3/2 power of the specific speed.

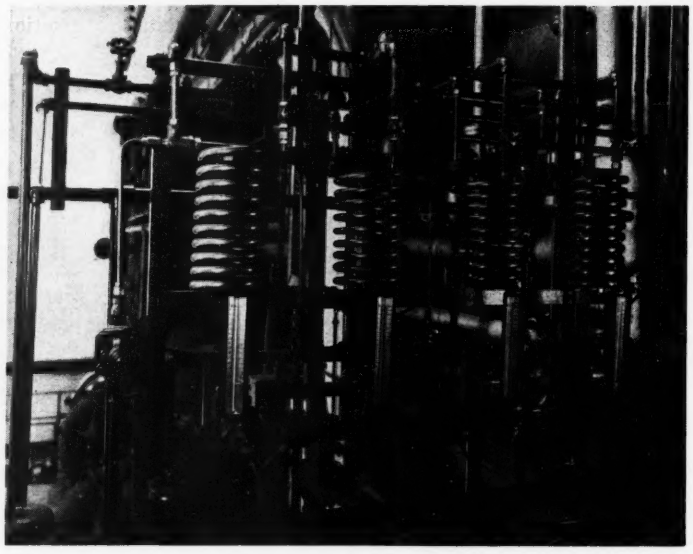
Both the disc friction and leakage losses decrease with the increase of specific speed. For the same water horsepower the bearing and stuffing box friction are substantially constant (if stuffing boxes are under the same pressure). Then the fact that pump overall efficiency is increasing rapidly at first up to about $n_s = 1750$, then stays practically constant from $n_s = 1750$ to 3500, and after that begins to decrease slowly, indicates that the hydraulic efficiency is decreasing for specific speeds over 1750. This is explained by the fact that hydraulic losses for high specific speed, low head pumps, constitute a greater percentage of the total head than for high head, low specific speed pumps.

The axial thrust of two similar pumps of different size and speed is in direct ratio to water horsepower and inverse ratio of square root of the head.

The axial thrust of two pumps of the same water horsepower, but of different specific speed, size and speed, varies inversely as the radial velocity through the impeller eye.

ON CLASSIFICATION OF COALS the Technical Committee of the A.S.T.M. report progress in formulation of requirements. Suggestions are being considered for improvement in setting the boundary line of fixed carbon between low-volatile and medium-volatile bituminous by possibly subdividing each of those groups into 3 subgroups. Chart has been prepared to show relative importance of chemical and physical properties of coals for various uses. Progress is reported in formulating a method of test for screen analysis of bituminous to cover screen specifications, sampling procedure and method of making the test. The principle has been accepted by describing coal sizes in terms of limiting screen sizes with tolerances for over and under size.

Some of the Boiler and Turbine Room Features That Contribute to the High Overall Efficiency and Reliability of This Modern Station*. By C. E. Miller and M. J. Boho, Potomac Electric Power Co., Washington, D. C.



Control Features of Buzzard Point Station

BUZZARD POINT STATION of the Potomac Electric Power Co. was placed in operation early in November, 1933. The initial installation consists of one 35,000 kw. General Electric turbo-generator and two Babcock & Wilcox 375,000 lb. per hr. cross drum boilers, direct fired by Riley pulverizers. Steam conditions at the turbine throttle are 675 lb. per sq. in. and 835 deg. F.

Use of direct contact type feedwater heaters and the operation of one boiler and turbine as a unit has demonstrated the desirability of the numerous automatic controls provided by the designing engineers, not only from the standpoint of ease of operation but also from the point of view of overall station efficiency and reliability. For this reason it is believed that the control features at Buzzard Point will prove interesting to those concerned with central station operation.

Boiler Room

Coal and air for combustion are controlled automatically in accordance with steam demand by a Hagan control system operating from header pressure. Fuel feed is controlled by varying the speed of the d.c. motors driving the table feeders which supply raw coal to the pulverizers. Air is regulated by a combination of fan speed and damper control. Hydraulic couplings are used for variable fan speed operation. Constant speed, 900 r.p.m. squirrel cage motors drive the fans through the oil operated couplings.

A fan speed variation of from 20 to 98 per cent of motor speed is obtained by automatic regulation of the amount of oil in the hydraulic coupling drives. The supplementary use of dampers allows slightly faster response to demands in air supply in addition to extending the range of boiler operation to approximately 8 to 1. The combustion control system is flexible, allowing manual or automatic operation of fans, dampers or feeder speed while at the same time allowing easy changing of fuel-air ratio under automatic operation.

Control of primary air is novel and effective. Air flows in the neighborhood of 2500 c.f.m. per burner, are desirable in order to deliver the pulverized coal to the furnace at the desired fineness, to keep the coal from settling out in the burner pipes and to maintain the necessary burner tip velocity for proper combustion. As the primary air ducts to the mills, due to space limitations, are unsuitable for orifice installations, the burners themselves were used as metering devices.

The curve shown in Fig. 1 is furnished to the operators and in practice the burner differentials, shown by conveniently located gages, are maintained at the values corresponding to the various ratings. The burner differential is equal to the pressure in the burner coal pipe plus the furnace draft.

Flow of feedwater is controlled automatically by S-C regulating valves, operating from water level, and pressure regulating valves, maintaining a constant excess pressure ahead of the feedwater controllers. A Ruggles-Klingemann excess pressure control varies the speed of the wound-rotor motor driven boiler feed pumps.

Superheat control at ratings above 200,000 lb. per hr. is accomplished automatically by a Bailey temper-

*See Buzzard Point Plant Supplies Power to Capitol. By H. G. Thielscher, Power Plant Engineering November 1933, p. 478.

ature recorder controller operating a butterfly valve to deflect more or less steam through the deheater located between the primary and secondary superheaters.

In order to prevent corrosion in the air heaters at low ratings, a Leeds and Northrup multipoint temperature recorder controller, with its various thermocouples pressed into the coldest tubes, automatically operates to open a damper and recirculate hot air from the discharge of the air heater back to the forced draft fan inlet whenever any of the tubes get below 150 deg. F.

Controls just described make the boiler operation almost entirely automatic after the unit is placed on the line. Practically the only manual operations necessary are the starting and stopping of one of the pulverizers and the manipulation of the primary air dampers.

Heat Cycle

The heat cycle in use is striking in its simplicity. Figure 2 shows in outline the arrangement of the various components of the station. Steam is delivered to the turbine throttle at 675 lb. per sq. in. and 835 deg. F. It passes through the turbine to the condenser with extraction at the 7, 11 and 14 stages for feedwater

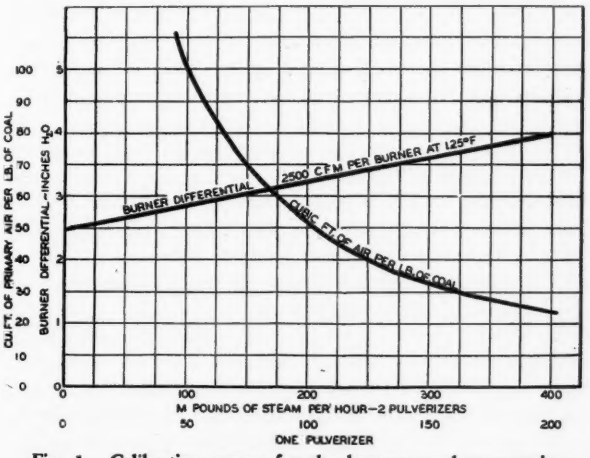

CU. FT. OF PRIMARY AIR PER LB. OF COAL
BURNER DIFFERENTIAL-INCHES H2O
BURNER DIFFERENTIAL
2500 CFM PER BURNER AT 125°F
CUBIC FT. OF AIR PER LB. OF COAL
M POUNDS OF STEAM PER HOUR—2 PULVERIZERS
ONE PULVERIZER

Fig. 1. Calibration curves for the burners used as metering devices for the primary air

heating in the three tray type Foster-Wheeler direct contact type feedwater heaters. The heaters are equipped with vent condensers and the condensate is deaerated at each stage. Vents are cascaded with the 14 stage venting to the condenser.

Condensate is raised to saturation temperature of the steam in each of the heaters. The use of desuperheating heater between the boiler feed pumps and the boiler results in an increase in feedwater temperature of 10 deg. F. above the saturation temperature of steam at the 7 stage pressure under full load conditions. All makeup is evaporated and admitted to the cycle at the 11 stage heater. Condensate is used in the evaporator condenser to condense the makeup vapor.

Control of condensate flow through the heaters presented a problem due to the fact that it takes approximately 3 min. for condensate to travel from the inlet of the 14 stage heater to the hot surge tank at full load, and, because the amount of steam extracted

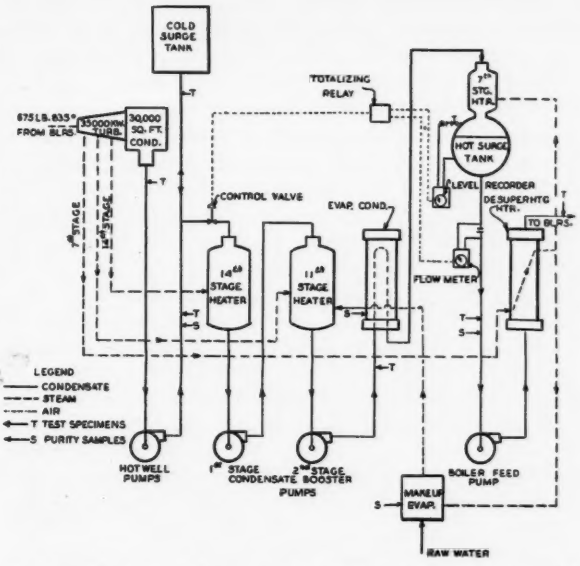


Fig. 2. Simple flow diagram of the station (a complete heat balance for 35,000 kw. is shown on p. 567 of the December, 1934, issue)

from the turbine depends to a large extent on the rate of condensate flow through the heaters. Smooth and accurate control of condensate flow was satisfactorily obtained, however, by arranging the Bailey control system to give approximately one-half the necessary valve opening from feedwater flow and the remainder from the hot surge tank level.

This is obtained as follows: An increase in demand by the feed pumps increases the differential across the orifice in the feed pump suction and actuates a flow recorder which in turn actuates an air relay valve. As water level drops in the hot surge tank, the level recorder also actuates an air relay valve. The effect of the two air relay valves is combined on a totalizing relay which in turn actuates the control valve admitting water to the 14 stage heater from the cold surge tank to make up for the increased demand. The equipment is so adjusted that a high water level is carried in the hot surge tank at light load and a lower level at full load. This drop in level thereby accommodates the delay of about 3 min. time in the travel of water from the condensate pump to the hot surge tank.

Another of the features of the station is the arrangement of float and level controls to protect the turbine from any back flow of water or steam. Each of the three extraction leads are equipped with flap type Schutte & Koerting oil operated non-return valves. These valves act as ordinary checks and close at any backflow either of steam or water. In addition, the oil pistons are connected to the oil pressure system which operates the turbine governor and main throttle.

Operation of the overspeed governor releases oil pressure from underneath the pistons and allows the three extraction valves to close simultaneously. In order to prevent backflow of condensate into the turbine, should the booster pumps fail to remove the condensate from the heaters rapidly enough, a float operated Mercoid on each heater operates to release oil pressure and close the corresponding non-return valve.

Another system of float operated Mercoid switches located on each heater at a slightly higher level operates to close a valve in the condensate line to the 14 stage when water rises in any of the heaters, caused by failure of the condensate booster or boiler feed pumps.

In addition to their safety features the above mentioned system of float operated switches simplifies station operation in that the hotwell, condensate booster and boiler feed pumps, may be started or stopped in any sequence desired.

Condensate Control

In order to insure long time reliability and low upkeep the engineers have worked out a system of chemical control which incorporates a number of novel features. Two L. & N. conductivity recorders make a continuous check on the purity of the water leaving the hotwell, entering the boiler, water in the desuperheaters, evaporator shell and evaporator distillate. The photograph in the headpiece gives a view of some of the cooling coils and purity cells used in connection with the recorders.

In addition to this continuous record, permanent connections have been provided for sampling boiler water at the water column, desuperheater and mud drum. Samples of saturated steam can also be taken as a check on carryover and also for comparison with the purity of the condensate to check condenser leakage. The usual connections for oxygen analysis have been provided at a number of points in the cycle.

Carefully weighed test specimens are installed in various locations as shown on Fig. 2, for the purpose of checking the effectiveness of the deaerating equipment and also the rate of deposit of any foreign material. To facilitate ease of examination, all of the samples are mounted so as to be removable with full pressure on the lines.

Chemical Feed

Ordinarly, the maintenance of proper boiler water conditions is simply a matter of mixing the desired quantity of chemicals and pumping it directly to the boiler drum by means of a high pressure pump. Two emergency conditions of particular interest have been provided for—maintenance of necessary alkalinity in the feedwater and soluble phosphate in the boiler drum at times of condenser leakage.

Condensate discharge flow meter operates a set of contacts from each 10,000 lb. of condensate leaving the condenser. The contactors through relays, operate a small motor to lower a swing pipe in the chemical tank a predetermined amount for each impulse. The chemical drains by gravity to the dilution tank and from there to the suction of the condensate pumps.

To maintain a definite presence of soluble phosphate in the boiler water a continuous feed to the boiler drum is provided. By means of an electrical timing device a high pressure pump is connected alternately to the phosphate feed tank and the clean water reservoir. By adjusting the time of feeding the chemical and the time of feeding clean water, any quantity of phosphate can be supplied directly to the drum and provide protection against any emergency condition.

Combustion Control Equipment

(Continued from page 96)

routine detail and leave him free to give more attention to combustion conditions, which may be adjusted manually from instrument indications.

Furthermore this type of regulation is known as position control as distinguished from metered control. That is, the dampers, fan and stoker steam valves are adjusted so that they take a definite position corresponding to the steam pressure change from normal. These controls must be set from operating tests, making the best possible adjustments for normal conditions. Varying characteristics of the different parts are coördinated as closely as possible by means of cams, toggles, special ported valves and compensating devices on the regulator itself.

Metered control, on the other hand, operates from steam, fuel and air flow quantities, as actually measured by suitable equipment, and maintained automatically at predetermined ratios. These ratios are changed at intervals, either manually or automatically from CO_2 or air flow-steam flow readings, to compensate for variations in the fuel supply.

Equipment Flexible

During the development period automatic combustion control systems were definitely limited to large installations, due to the high cost. This is no longer true, however, and for the past few years many manufacturers have been concentrating on the small and medium size industrial plant problem with remarkable success. Complete development and operating experience has made simplification of the actual equipment possible at greatly decreased costs while the increased market has made it possible to adopt quantity production methods for much of the equipment.

This does not mean that it is possible to buy a ready made control system and apply it indiscriminately without considering the characteristics of each piece of equipment involved. It does mean, however, that the present systems are made up of standardized parts, which in different combinations give a flexibility sufficient to meet all needs.

Not every plant needs full automatic control. In some cases manual control, either direct or through remote controls, is sufficient, in others partial automatic control is desirable although an increasingly large percentage of plants are finding economic justification for full automatic control.

After all this equipment is to the boiler what the governor is to the engine, regulating pressure as the engine governor regulates speed. It would be difficult to find an engineer who does not believe his governors are not only justified economically but are an absolute necessity, yet he operates his boilers without even considering a governor. This in spite of the fact that such a governor would enable the fireman to give attention to the auxiliaries and relieve him from the monotonous task of 'gage gazing' which can be done much better and more satisfactorily by mechanical means, the modern Genii of the Lamp, automatic combustion control; or, in the alphabetical spirit of the times, A.C.C.

Multi-Unit Heating Plant *Put Into Operation*

UNIQUE among heating plants is the multi-unit central plant, consisting of 120 General Electric LA-5 domestic oil furnaces arranged to operate automatically in a single battery, which has been installed during the past summer at Mount Holyoke College, South Hadley, Mass., and now in regular service.

This new central plant comprises the major portion of a total of 172 G. E. furnaces installed at Mount Holyoke in providing a complete new heating equipment for the college. Of the 53 buildings, 24 of the largest and most centrally located structures on the campus are heated from the central plant. The rest of the buildings are at more remote locations around the edge of the campus and are equipped with single furnaces or with furnaces in small groups, the largest of which numbers ten units.

Each of these outlying installations is individually adapted to the heating requirements of the building which it serves, a wide variety of heating systems being included—steam, vapor, hot water, and conditioned warm air. These smaller equipments are conventional in nature, whereas the new central plant is a substantial departure from previous practice in heating plant design.

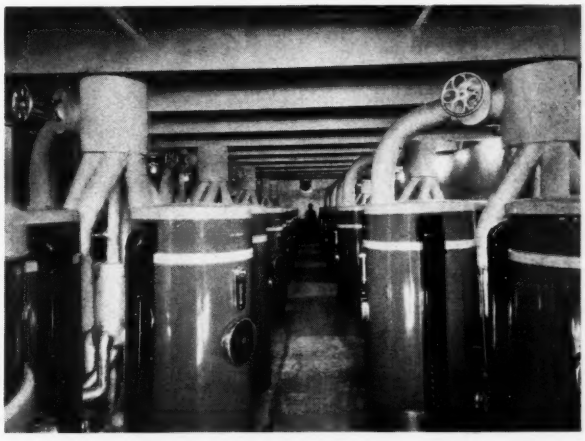
This plant is housed in a low one-story and basement building occupying the space formerly used for the storage of fuel. It is built back into the slope at the lower edge of the campus and is invisible from nearly all directions. A short ornamental obelisk serves as a high-velocity exhaust nozzle for the products of combustion, and its real purpose is not readily discovered.

The steam-generating battery itself consists of 24 groups of five furnaces arranged in four rows of six, the furnaces in each group being arranged in a circle with all steam, feedwater, oil and flue pipes leading directly down into the basement. Groups operate as single units, although any of the furnaces comprising a group may be withdrawn from service for inspection or adjustment.

Operation of the furnace battery is controlled by an automatic regulator, actuated by the pressure in the main steam drum, which brings successive groups into service to the number required to maintain steam pressure between 8 and 11 lb. per sq. in. Draft for the proper exhausting of products of combustion is provided by induced draft fans installed in duplicate in the basement of the plant. Fan speed is governed automatically by the number of furnace groups operating, thus providing an essentially constant draft on each furnace regardless of the total load on the plant.

Boiler feed pumps, also in duplicate, maintain proper water levels in the boilers, while oil pumps bring the fuel from large underground storage tanks outside the plant to a distributing header in the basement. This header is at atmospheric pressure, each furnace taking its fuel from it separately by means of the oil pump which is a part of the furnace mechanism.

Steam, automatically produced to maintain a constant pressure range in the main steam drum, is distributed to the 24 buildings on the central system through underground mains, nearly all of which were available from the old system. The system of control which governs this distribution was provided by the Warren Webster Co., embodies great flexibility, and permits regulation of output down to 10 per cent of the maximum. This has been accomplished without replacing existing radiators, although in most of the buildings these are on "one-pipe" systems, which ordinarily are not considered adaptable to regulation.



A few of the G. E. oil furnaces in the central heating plant at Mount Holyoke College

Balancing of radiation to heating requirements was effected, after careful heat-loss surveys, by orificing the radiators.

In each building, a main steam valve, controlled automatically from the central plant, admits steam to the radiators in the building once every 8 min. The duration of admission in each 8 min. period is varied automatically between 45 sec. and 7 min. under the guidance of an outdoor thermostat at the central plant. In the off period, water from condensed steam drains back from the radiators. This arrangement not only provides a wide variation in the amount of heat that may be supplied to a building, but also prevents water hammer and interference of steam and condensate in the one-pipe systems.

THE COPPER CENT is the humblest coin that bears the imprint of the United States government. The only field in which it really plays an important part is in the purchase of electric current, says the New Jersey Public Utility Information Committee. Here is what a single penny will do: run a clock for 83 hr.; a fan, 6 hr.; heating pad, 2 hr.; iron, 16 min.; percolator, 25 min.; lamp, 3 hr.; radio, 1 hr.; sewing machine, 6 hr.; space heater, 16 min.; toaster, 20 min.; vacuum cleaner, 50 min.; waffle iron, 15 min., and washing machine, 40 min. Where can you buy more for one cent?

ELECTRICALLY DRIVEN *Steam*

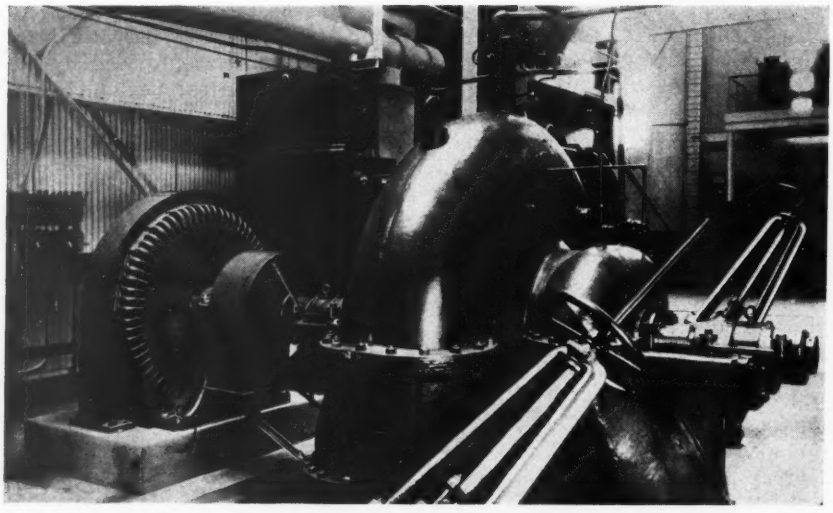


FIG. 1.

520 Hp. 360 r.p.m. 2300v. synchronous motor direct connected to circulating pump. Control panel can be seen in center, rear

ALTHOUGH the purpose of steam power stations is the generation, not the utilization, of electric power, nevertheless all stations use power in considerable quantities for driving necessary auxiliary apparatus. Most of the auxiliaries in the early stations were driven by steam engines or turbines, but the growth of confidence in electric drive has resulted in the gradual replacement of steam drive by electric drive in many of the old stations.

There are many reasons why electric drive is used and to account for the widespread confidence in this type of drive. The most important of these are:

1—The development and use of the house turbine with its relatively low water rate as compared with the water rates of small capacity turbines, each driving an individual auxiliary.

2—The development in the art of motor and control manufacture, resulting in extreme reliability.

3—The appreciation by the motor and control manufacturer of power plant auxiliary requirements, resulting in improved characteristics.

4—The increased use of multi-stage bleeding.

5—The practice of sectionalizing both the main and auxiliary power buses.

6—The use of a multiplicity of auxiliary units (especially in the case of large turbo-generators) instead of a single large unit.

The principal advantages of electric drive may be summarized as follows: 1—Reliability. 2—Simplified station layout. 3—Ease of installation. 4—Low initial investment. 5—Simplified control.

Simplicity and reliability are desired wherever electric drive is used, but reliability is of first consideration in case of power station auxiliaries. For industrial applications, low first cost or greater economy may come first. In the average industrial application, most motors are started and stopped many times per day and few operate for long periods without stopping. This is not the case, however, with station auxiliaries as they are subjected to long, continual periods of operation. From the control standpoint, continual operation is important as infrequent operation of copper-to-copper contacts may result in oxidation, with consequent overheating of the contactors.

Essential and Non-essential Auxiliaries

Aside from the main generating units, switchgear, transformers and control boards, the principal machines and devices in steam generating stations are commonly known as station auxiliaries. These may be considered under two classifications, "essential" and "non-essential" auxiliaries.

"Essential" auxiliaries are those which must be kept in practically continual operation in order not to impair the ability of the station to carry its load. Such auxiliaries include the boiler feed pump, circulating pump, condensate pump, forced draft fan, induced draft fan, primary air fan, pulverized fuel feeder, stoker, and unit-type coal pulverizer.

"Non-essential" auxiliaries are those which can be taken out of service for appreciable periods without materially affecting the ability of the station to carry its load. In this class appear the air compressor, central coal pulverizer, clinker grinder, coal crusher, coal handling equipment, conveyors, service pump, and ventilating fan.

The "essential" auxiliaries seldom can be shut down for longer periods than from 15 sec. to 3 min., while with the "non-essential" auxiliaries the allowable time of interruption may be indefinite.

AUXILIARIES *for Generating Stations*

By S. C. SMITH, Industrial Engineering Dept.
General Electric Company

To increase the dependability of the whole station, auxiliaries of major importance frequently are installed with duplicate reserve equipment, while auxiliaries of minor importance are installed without reserve equipment. The following tabulation indicates modern trends in this respect.

Unit	Reserve Capacity
Boiler feed pump	100 per cent spare capacity, or one spare for two or more operating units.
Circulating pump	Two pumps per condenser, or 100 per cent spare capacity.
Condensate pump	100 per cent spare capacity.
Draft fans, primary air fan, pulverized fuel feeder, pulverizer and stoker	Seldom any spare capacity provided.

Any type of motor and control used with the "essential" auxiliaries should be so arranged that a momentary interruption of voltage will not shut down the drive. In case of a prolonged interruption of voltage, the auxiliary should automatically go back into operation with return of voltage. With "non-essential" auxiliaries it is usually satisfactory to start them by hand after an interruption of power.

Motors

Nearly all power plants generate alternating current power and therefore it is advantageous to use alternating current motors as far as possible. Most of these motors as built today have the windings adequately braced for full voltage starting, and in general the mechanical construction of the motors are adequate for the long continual service encountered in power station auxiliary drive.

Where open motors built in skeleton frames are subjected to dripping water, oil, etc., drip covers may be provided at a small additional cost. In recent years, considerable preference has been shown for the closed box-frame construction for motors in the larger sizes to give the same protection. Open motors driving draft fans, stokers, pulverizers, clinker grinders, etc., should have insulation to guard against the dust and dirt present in the ventilating air taken by the motors.

If there is considerable coal and ash dust, dirt, etc., around the motor installation, some type of totally enclosed motor construction should be used for small and medium size machines. Large motors may be arranged for forced or self ventilation, bringing clean air to the motor through pipes or ducts, where the cost is less than using totally-enclosed, fan-cooled construction.

Motors having commutators or collector rings may have solid covers over the upper openings in the end shields on the commutator or collector ring end to give additional protection. In some cases it is desirable to totally enclose the rings but still to use the open frame motor. The rings are then mounted outside the bearing housing in dust-tight enclosures.

The various types of motors used are given below with a general description of each type.

1. Single-speed, Squirrel-cage Induction Motors

Wherever possible, the single-speed squirrel-cage induction motor should be used as it is the simplest, sturdiest and least expensive type of motor available. Also, its control is extremely simple. Because of its low cost, the normal starting current, normal starting torque design is generally used where unusually high starting torque or unusually low starting current is not required. Motors of this design have high efficiency and high power-factor.

In some cases, the starting inrush current to motors of this design may be undesirably high, thus justifying the slightly increased cost of the low starting current,

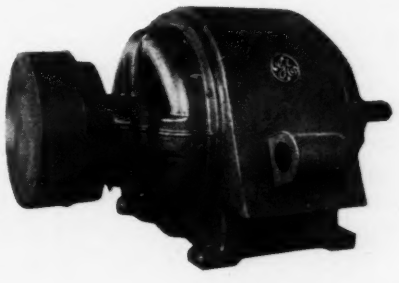


FIG. 2. Induction Motor with outside enclosed collectors

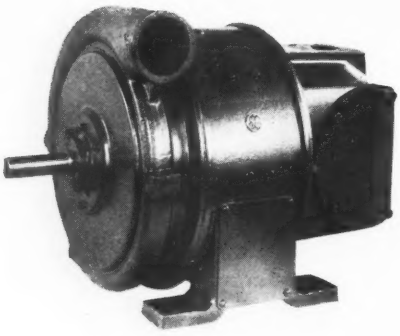


Fig. 3. Enclosed self - ventilated motor

normal starting torque type of motor. Then efficiencies are equal to or only slightly lower than those of normal starting current motors, but the power factors may be several points lower. Motors of both designs are used to drive boiler feed, circulating, condensate and service pumps, and forced and induced draft fans.

For a few drives such as conveyors, crushers, and pulverizers, higher starting torques than are provided by the above designs usually are required. Low starting current high starting torque motors are available for these cases. Some sacrifice in efficiency and power-factor are required to obtain the high torque and low current characteristics.

2. Wound-rotor Induction Motors

Where speed changes are required, wound-rotor motors are used more frequently than any other type. These motors are also commonly used where the starting current of squirrel-cage motors are too high or where the advantages of increment starting current and torque are desired.

The wound-rotor motor possesses adjustable-varying-speed characteristics and is widely used to drive forced and induced draft fans and pumps. Speed reduction is obtained by inserting external resistance in the secondary circuit. Because of its series characteristics, the speed regulation of the motor increases with the resistance in the secondary circuit and limits the recommended speed reduction to 50 per cent or 60 per cent, since with greater reduction it becomes unstable—i. e., small changes in load torque result in large changes in motor speed. Wound-rotor motors are not usually recommended for driving stokers or pulverized fuel feeders where the torque fluctuates widely and a wide speed range is required.

The efficiency of a wound-rotor motor when operating with no external resistance is slightly lower than that of a comparable squirrel-cage motor. The efficiency decreases as the speed is reduced and at 50 per cent speed for a given torque is approximately 50 per cent of that which the motor would have at the same torque with no external resistance in the secondary circuit.

3. Multi-speed Induction Motors

a. Squirrel-cage multi-speed motors.

Multi-speed, squirrel-cage, induction motors in power stations are used chiefly for driving circulating water pumps, stokers and draft fans. These motors may be designed for two, three or four definite speeds, and the principal use of two-speed motors is for circulating pumps. Three and four-speed motors are used for stoker and fan drive.

b. Wound-rotor multi-speed motors.

When neither the standard wound-rotor motor nor multi-speed squirrel-cage motor provides sufficient speed reduction or the desired number of steps, multi-speed wound-rotor motors are sometimes used. This type of motor is sometimes used for fan drive and compares favorably in cost with two separate wound-rotor motors, as well as occupying less space.

4. Alternating-current Brush-shifting Motors.

a. Shunt type motors.

This type of motor is an adjustable-speed machine with a speed characteristic similar to that of a shunt-wound direct-current motor; i.e., the speed is practically constant for a given brush setting irrespective of load changes. It is, therefore, commonly referred to as a shunt-type a-c. brush-shifting motor. The maximum commercial voltage for which it is available is 550 volts.

Standard motors are available in capacities up to about 50 h.p. with speed ranges of 3:1 and 4:1. The following table indicates the usual speeds for which standard 60-cycle motors are designed. It should be noted that these motors are capable of operating above synchronous speed.

Horsepower	R.P.M.	Poles
	3:1 Speed Ratio	
3 to 15 inclusive	1650/550	6
25 to 40 inclusive	1250/415	8
50	1000/333	10
	4:1 Speed Ratio	
2 to 10 inclusive	1760/440	6
20 to 30 inclusive	1333/333	8
40	1070/267	10

Speed adjustment for this type of motor is obtained by shifting the brushes by hand, remote mechanical (sprocket and chain) or electrical (pilot motor) means.

The chief uses for these motors in power stations are for driving stokers and coal feeders where adjustable speed in fine steps over a wide range is required. They are also used to drive small fans but cannot be built with sufficient capacity to handle the larger units. Because such a machine includes the elements of an induction motor and a direct-current motor, its cost is higher than that of a wound-rotor motor but com-

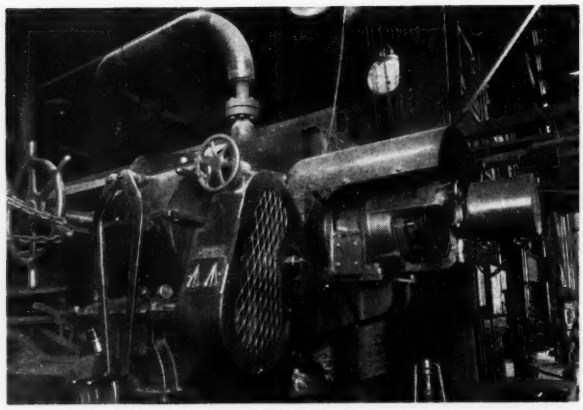


Fig. 4. 6 pole 10/2.5 hp. 1760/440 r.p.m., 440 v., 3 phase, 60 cycle, adjusting speed brush shifting motor driving a chain grate stoker

pares favorably with the cost of a direct-current motor and necessary a-c. to d-c. motor-generator set. Moreover, it requires less space, is generally more efficient, and requires very simple control. Its power-factor is high at top speeds and holds up well at reduced speeds.

b. Series-type motors.

In larger sizes, adjustable-speed a-c. brush-shifting motors having a speed characteristic similar to that of a wound-rotor motor are available.

They can be built for operation on either high or low voltages and are available for speed ranges up to 3:1, and in special cases somewhat more. For a 3:1 range and fan drive, the maximum motor output for a 60-cycle machine is about 15 h.p. per pole. Where greater capacities are required, the employment of special windings practically doubles the obtainable output per pole but adds considerably to the cost.

These motors are used in power plants chiefly for driving the draft fans. Although necessarily built with a commutator, the voltage between segments is low and moderate conditions of coal and ash dust generally have no detrimental effects.

In general, the speed of the motor can be adjusted by shifting the brushes by any of the methods previously described.

5. Direct-current Motors.

Although a few power stations use direct-current equipment extensively, direct-current motors in general enjoy only a limited field of application in power plants. For auxiliary drive, their use is practically restricted to stoker and fuel feeder applications although a few direct-current motors are used to drive fans and pumps. The choice of direct-current drive for stokers and fuel feeders is based primarily on the suitability of the direct-current machine for wide speed adjustment in small steps.

6. Synchronous Motors.

The number of synchronous motors applied to power station auxiliaries is limited, chiefly because induction motors are simpler.

However, induction motors designed for low speeds have low power factor and efficiency, and are relatively expensive. Low-speed synchronous motors, on the other hand, can be designed for unity (or leading) power-factor and high efficiency, and are generally less expesive than induction motors of comparable rating for speeds below 450 r.p.m.

Thus, for slow-speed drives such as reciprocating compressors, certain types of pulverizers, circulating pumps and vacuum pumps, direct-connected synchronous motors are especially applicable, as better operating characteristics are usually obtained at a lower investment.

7. Gear-motors

The recent development of gear-motors provides an efficient low-speed drive which is applicable to many relatively small power station auxiliaries, such as stokers, fuel feeders, coal handling equipment, damper drives, etc. These gear-motors are available for operation on direct-current, single-phase or polyphase a-c. circuits.

Editor's Note. The question of control of electrically driven auxiliaries will be discussed in another article by Mr. Smith in a subsequent issue.

Winter Care of Air Conditioning Equipment

By L. G. Huggins*

THERE ARE a number of precautions which should be taken in preparing an air conditioning system for the inactive winter season. The refrigerant should be removed from the system and stored in the liquid receiver of the condensing unit, to avoid loss due to leaks occurring in the winter. With a compressor standing idle for a long period of time, the oil on the face of the seal may be dissolved by the refrigerant, leaving this seal face dry and the possibility of refrigerant escaping at this point is greatly increased.

All water should be removed from the condenser, and in the case of water-cooled compressor, from all cooling jackets. Many condensing units are built with spiral coils so arranged that water will not drain from them completely by gravity. Therefore, the safe procedure is to blow all water out of the cooling coils by means of compressed air. A small tank of compressed air is usually carried to the job by the service man for this purpose.

Many condensing units have automatic water regulating valves which are normally closed when the condensing unit is not in operation. It is usually possible to remove the valve seat from these valves so that water can be readily blown out. Unless this valve is opened, it will not be possible to completely remove water from the system.

After water has been removed from the condenser the safest procedure is to disconnect the water pipe leading to the condensing unit and cap this pipe. Usually a union will be found near the machine which will make it easy to remove this water connection. This precaution will prevent tampering with the water valve during the winter or accidentally admitting water to the condenser.

All unpainted iron or steel surfaces of the condensing unit, such as couplings, shafts, and other bright parts, should be wiped with an oily cloth to provide a thin film of protecting oil to prevent rusting during the winter. A cover of heavy paper, muslin, or similar material should be placed over the condensing unit and securely tied into place. This cover will keep the unit clean and free from dust or dirt.

Electric power and control circuits to the condensing unit should be opened to prevent accidentally starting the unit during the winter. This can usually be accomplished effectively by removing the fuse from the safety switch, and tagging the safety switch calling attention to the fact that the circuits are disconnected and should remain disconnected until desired to again start the apparatus. In clearing the electrical circuits to the unit, the engineer should make sure that he does not also interrupt the power circuit to the fans in the air conditioning unit or the control circuits for the humidifier or heating equipment if this part of the air conditioning unit is to be used for winter operation.

*Westinghouse Elec. & Mfg. Co.

Replacement of Coal Fired Boilers by Electric Steam Generator

Montreal Dairy Plant Installs Electric Boiler Equipment Capable of Furnishing 10,000 Lb. of Steam Per Hour.

ELECTRICITY is used to make steam, instead of the customary process of steam being used to make electricity, in a new hydro-electric steam generator recently put into service in the Montreal milk and ice cream plant of J. J. Joubert, Limitee. This is believed to be the first installation of its kind for large scale dairy work in Canada or the United States.

J. J. Joubert is one of the outstanding and largest dairy establishments in Montreal. It was incorporated in 1910 by members of the Joubert family and, despite its growth and success, it has remained largely a family-operated enterprise.

Four coal-fired steam boilers of 150 hp. each are replaced in the Joubert plant by the new steam generator which is of the water resistance type. In such an installation, electrodes are submerged in water and heat is generated by the passage of current through the water between the electrodes, the water itself forming the resistance.

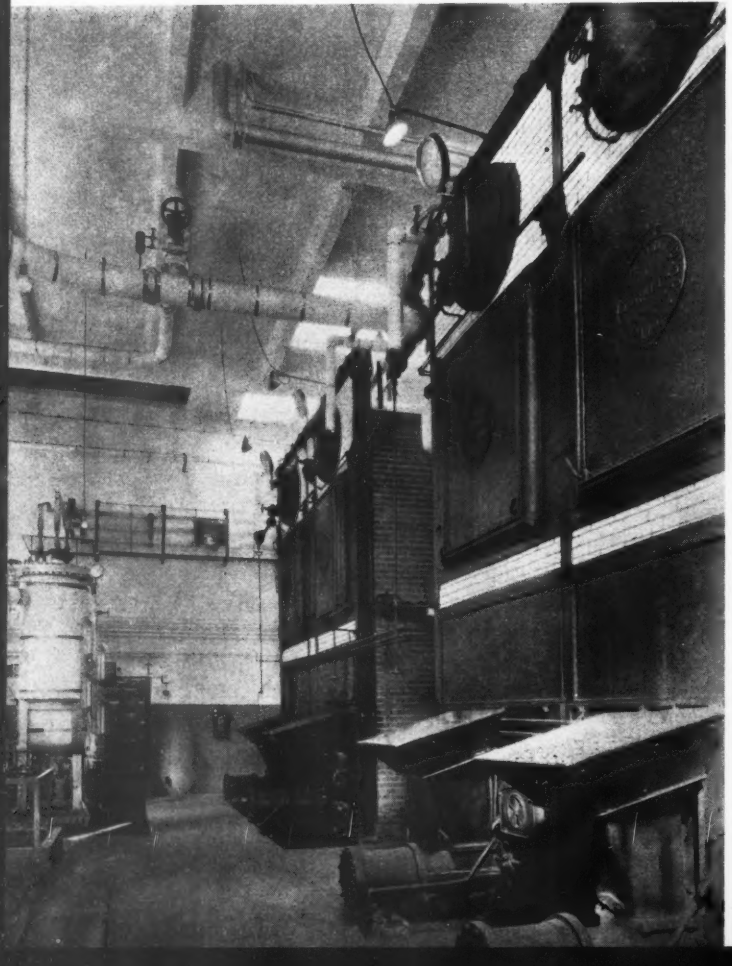


Fig. 1. View of boiler room, showing old coal fired boilers and new electric steam generator

It is estimated that, at the present price of coal in Montreal, steam made in coal-fired boilers would cost about 46 cents per thousand pounds. During the first month of the new generator's operation, the steam made by electricity cost 32 cents per thousand pounds, a reduction of 14 cents. The plant is using about 90,000 lb. of steam a day.

"The new generator provides unusually clean plant conditions as well as favorable cost operation," it was declared by E. J. Lockwood, consulting engineer from New York City, who recommended and supervised the installation. "We have eliminated smoke completely and have ended fuel waste and standby losses. With this generator, it is possible to get steam up to 110 lb. in 15 min."

During the past two depression years there has been a trend throughout Canada toward the use of hydro-electric power for the generation of steam. Various Canadian paper mills were early users of electricity for this purpose and two years ago it was declared that some 87 per cent of the installed capacity of electric boilers was in paper mills.

Novel Method of Control by Salt Solution

One of the unusual features of the Joubert installation is its ease of control. The flow of steam can be regulated by a control system which injects a small amount of salt into the boiler feed water to increase its conductivity. Various other control mechanisms are on the panel such as safety switches and low water alarm, as well as duplicate safety valves.

Mr. Lockwood's attention to the possibility of installing an electric steam generator in the Joubert plant was attracted by the activity in this direction of the paper mills.

"We had a proposal from a power company to furnish electric power for one mill per kw. hr.," he declared. "That meant that the power company was willing to furnish the heat equivalent of 3415 B.t.u.'s for one mill. Our steam at 100-110 lb. pressure contains a total of about 1189 heat units.

Boiler Efficiency of 98 Percent

"If our average feed water temperature is 90, we had an equivalent of 3 lb. of steam for one mill, or a steam cost per thousand pounds of 33⅓c. Our feed

in Dairy Plant Saves 30%

water temperature is very much above 90, so that we are getting even better than 3 lb. efficiency per kw. from this boiler—the only losses possible being the radiation on the boiler of the amount of heat lost in the blow-downs to correct the mineral content of the water. With the installation of a heat exchanger, most of the heat from this blow-down water is recovered and the boiler efficiency is nearly 98 per cent."

The new Joubert boiler is of nominal 200 hp. capacity with an overload rating of 60 per cent, giving a possibility of 300-325 hp. According to the steam flow meter, 10,000 lb. of steam have been taken per hour over a period of several hours, without trouble. The voltage used is 12,000 v.

Three cast iron electrodes about 10 in. in diameter are arranged in a triangular form within the boiler which is about 30 in. in diameter and 10 ft. in height. The space occupied by the boiler is about 10 ft. square and requires for dismantling a total height of 25 ft. in order to raise the electrodes clear of the top of the boiler for any possible repairs or cleaning.

Without any water in the boiler no current flows but as soon as water is pumped into it and the bottom of the electrodes are covered, current starts to flow. The more the electrodes are submerged, the more steam is obtained from the boiler. In other words, the amount of steam is increased by pumping additional water into the boiler.

"There is another control also, called the Eaton system, by which the flow of steam can be increased by the injection of a small amount of salt into the boiler feed water to increase its conductivity," Mr. Lockwood said. "This control functions almost instantaneously and is operated automatically from the electric switchboard.

"As the pressure increases beyond a predetermined point, the blow-down valve is opened automatically and a small portion of the concentration of salts in the bottom of the boiler is blown off. The current flow at once is decreased on account of the lessened conductivity of the water and the steam pressure decreased.

"The steam pressure can also be decreased by throttling the amount of water fed to the boiler and lowering the water level. This is accomplished by a regulator which maintains a constant pressure on the feed water. As pressure drops in the boiler, the pump increases its speed and pumps more water which gives greater submergence on the electrodes and at once increases the flow of steam."

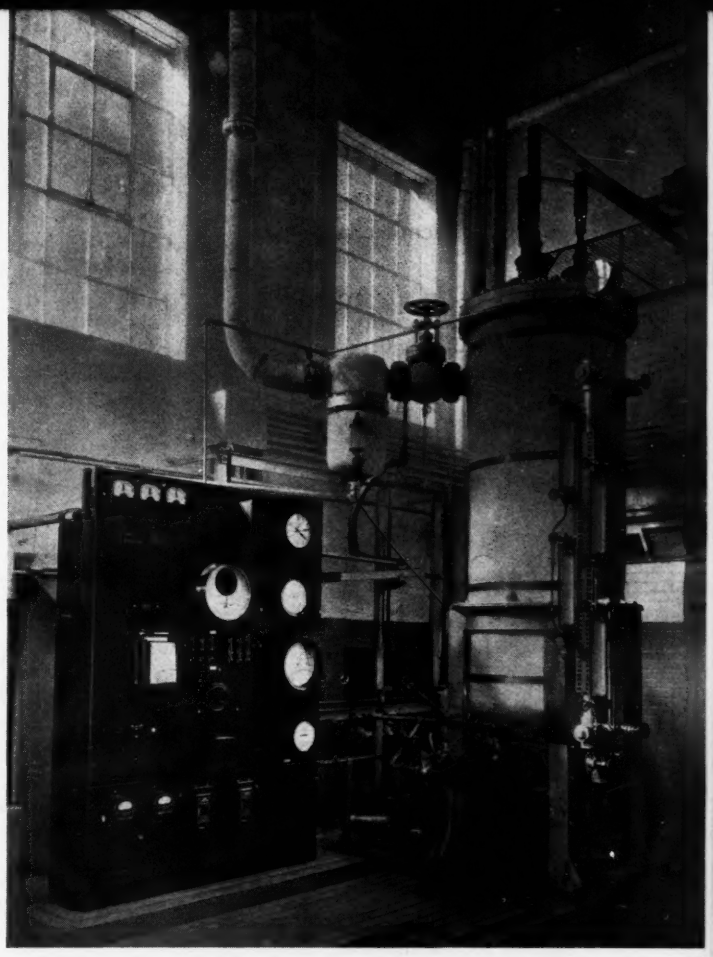


Fig. 2. Electric steam generator and control panel

The main switch of the generator is of remote control from the switchboard and disconnect switches are mechanically interlocked with the main oil switch. It is impossible to operate the disconnect switches before the oil switch is opened.

Fluctuation of Steam Load Easily Handled

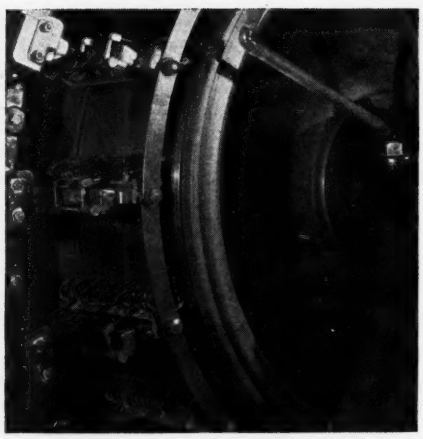
Formerly three of the four coal-burning boilers in the Joubert plant were in operation most of the time because of the fluctuation of the steam load. This fluctuation has been almost entirely eliminated by the ability of the electric boiler to function almost instantly on a varying load. To smooth out the load still more, one of the coal-fired steam boilers is being used as a steam accumulator.

The use of electric steam generators offers many advantages but of course it is feasible only where a considerable amount of power is available at extremely low rates. This means, of course, that it must be hydro-electric power. But where they can be used as in this particular instance this type of equipment is extremely desirable. It is clean, reliable, and convenient. Their safety and freedom from fire and explosion risk makes it possible to install them where fuel equipment could not be used or where the insurance cost would be excessive. Their operation is automatic, relieving the user of the care, labor and attention needed with fuel apparatus. Their use, however, is entirely dependent upon the relative costs of fuel and electricity.

Further Consideration
of Brush Phenomena

By R. M. BAKER

Research Engineer
Westinghouse Electric & Mfg. Co.



Voltage Drop *in* Electrical Sliding Contacts

IN the November 1934 issue we presented an article by R. M. Baker of the Westinghouse Electric and Manufacturing Co. on the subject of Electrical Sliding Contacts. This article discussed some of the fundamental aspects of brush operation. Now, in another article, Mr. Baker continues his discussion of this interesting subject with the practical and theoretical consideration of Voltage Drop in Sliding Contacts. As in the case of the first article this present article is presented here by special permission of the Electric Journal in which it first appeared. These studies in brush action have already given us a much better understanding of commutation and collecting ring problems and will undoubtedly result in improved operation.

WHEN we observe the polished face of a carbon brush that has been collecting current from a slip ring, it appears mirror-like in its smoothness. As compared to optical surfaces, however, the polished brush surface would be considered very rough. If the surface is viewed under a microscope, one observes first of all the identity of the indvidual grains of the materials used in making the brush. Furthermore, if the microscope is focused carefully on the individual grains, they are found to differ in height by several ten thousandths of an inch; that is, there are certain very small areas that are high or protruding and others that are lower or depressed. An observation of the ring surface on which the brush slides also shows such irregularities, depending in magnitude upon the degree of finish on this surface.

With this knowledge of the roughness in the contact we can understand the manner in which the contacting surfaces come together. To simplify the mental picture, assume that in comparison to the roughness of the brush face the ring surface is perfectly smooth. As the brush is pressed at first very lightly against the ring surface, only the high point or points of the brush face will bear on the ring surface. Since the brush material is somewhat elastic, a further increase in pressure will deflect the original small points of contact and some of the depressed points of the brush face will come into contact with the ring surface. This continues until full brush pressure is reached and the contact is completely formed. Obviously the balance in each case occurs when the sum of the small areas where the brush touches the ring is sufficient to support the applied brush pressure without further deflecting. Now, some of the small supporting areas (the newly formed areas) will not be supporting as great a share of the total brush spring pressure as those small areas at which the brush material has been further depressed. The ultimate load which a small area can carry is limited of course by the crushing strength of the carbon. Let us assume that this is 20,000 lb. per sq. in. and that we have a pressure of 2.5 pounds on a contact area of one square inch. To carry the total brush pressure of 2.5 lb., an actual contact area of only 2.5/20,000 or 0.000125 sq. in. would be required. That is, to support the brush spring pressure, it is necessary to have, at any one time, only about one one-hundredth of one per cent of the brush face in contact with the ring. This figure checks very well with what is found from electrical measurements. The condition in the contact is obviously a dynamic one. Conditions of the surfaces are continually changing. There is some abrasion as well as impacts between small irregularities on the two surfaces to cause this change. The greatest factor

by far, however, is the so-called electrical wear of the brush. This phenomenon appears to take place in such a manner as to maintain practically a constant condition of roughness in the brush face.

Types of Contacts

The foregoing picture of the mechanical conditions in a sliding contact is obviously applicable regardless of the material from which the ring is made. The only requirement to be fulfilled is that the ring surface be essentially smooth. The ring may be made from iron, copper, brass, gold, or platinum. It may even be made from carbon, although in this case the roughnesses of the ring surface will be comparable in magnitude to those in the brush face. The electrical contact drop on the different rings will, however, be quite different, for a mechanical contact between the brush and ring is not necessarily a good current-carrying contact. This means that electrically, sliding contacts may be divided into two major groups or types: contacts with, and contacts without oxide films. A given ring-and-brush combination may in some cases be capable of producing a contact of both types. For instance, the contact between a graphite brush and a silver ring shows the presence of an oxide at room temperature; whereas on heating the silver ring to 200 deg. C. the oxide disappears, and the contact has all the characteristics of an oxide-free contact.

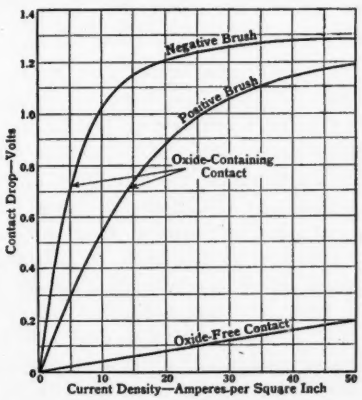


Fig. 1. Characteristics of sliding contacts. The shape of the curves results in an explanation of how current is conducted across a sliding contact

Electrical Conditions

Oxide-Free Contact—What kind of a volt-ampere characteristic should be expected from an oxide-free contact? Suppose a graphite brush is operating on an oxide-free metal ring, say, a gold ring. As already pointed out, the current must converge in the brush to the small areas of contact, distributed uniformly over the brush face; and since their total area constitutes only about one one-hundredth of one per cent of the total area of the brush face, they are extremely small. Consequently, the current must concentrate and flow through a greatly reduced section of brush material just before it flows across contact and into the ring. Since the cross section of the brush material through which the current flows is small, it has considerable resistance, and there is in the brush, as a result, an appreciable voltage drop. No method of measuring contact drop can distinguish between this drop in the brush material very near the brush face and an actual drop in the contact. We therefore measure this voltage and call it, perhaps falsely, contact drop. There is no actual drop in the contact, for the brush makes intimate electrical contact with the ring. Since the resistance we measure in such a contact is only that of the carbon material, it must remain constant so long as the resistivity of the carbon is not changed as a result of heating. Although the current density in the restricted region is very high, the temperature rise is small.* This type of contact, then, would be expected to have a constant resistance, or linear volt-ampere characteristic. Observations verify exactly this conclusion.

Oxide-Containing Contact—The familiar contact between a carbon brush and an iron or copper ring is much more complicated. These metals oxidize very rapidly when exposed to the air, and a large part of the measured contact drop is due to the disturbing influence of the oxide. The mechanical conditions in the contact are probably not directly affected by the presence of the oxide, for the thickest oxide films are still thin as compared to the mechanical roughnesses of the polished brush face. We must believe that the current of the brush converges in the brush to the small contact areas in the brush face just as if the oxide were not present. To get across into the ring it must, however, subsequently flow through the thin sections of oxide which insulate the brush, at the small areas of mechanical contact, from the ring. The contact drop in this case is made up of two parts: the resistance drop just inside the brush face, and the additional drop in the oxide.

Typical volt-ampere curves for a graphite brush operating on a copper slip-ring are shown in Fig. 1. The shape of these curves has been much discussed, for the explanation must result in an understanding of how current is conducted across a sliding contact. The characteristic of an oxide-free contact is also shown in the straight line curve of Fig. 1. Even at normal current density the resistance of the oxide-containing contact is still considerably higher than that of the oxide-free contact. As the current density is increased through the oxide-containing contact its resistance gradually decreases and would apparently reach the low value of the oxide-free contact at sufficiently high current density. Thus one is lead to the conclusion that the decrease in resistance of the ordinary contact with increasing current is due to a breakdown or reduction in resistance of the semi-insulating oxide film. The exact process by which this is accomplished is only poorly understood at present. The important thing to realize is that sliding contacts, when clean, do not exhibit the peculiarities ordinarily attributed to them. The mechanism of current transfer involves no new phenomena and is easily understood. The peculiar variable-resistance characteristic of a sliding contact appears only when the contact is disturbed by a semi-insulating oxide film.

*"Electrical Sliding Contacts," R. M. Baker, on page 528, November 1934 issue.

Practical Application of Oxide-Free Contacts

An oxide-free contact finds an important application in collecting small currents, such as required by metering circuits, from the rotating parts of electrical machines. If the ring or brush used in collecting such currents is oxidizable, it is possible to build up a high resistance in the contact, which will introduce serious errors in the readings of instruments. For instance, a carbon brush having a contact area of one square inch and operating on a copper slip-ring with a resistance of only about 0.02 ohm at a current density of 50 amp. per sq. in. will have a resistance of several hundred ohms at a current of a few milliamperes. An oxide-free contact of the same size would have a contact resistance of only about 0.004 ohm at normal current

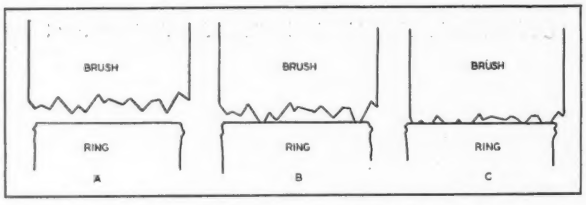


Fig. 2. An exaggerated view of a carbon brush coming in contact with a slip ring. The microscope shows a roughness of the grains, (a), even when the brush appears mirror like, and only the high points touch the ring surface when the brush is first slightly pressed against it. Full brush pressure deflects the higher points and brings into contact some of the lower points. (c) This condition is dynamic, for the surface characteristics change

density and more important, would maintain this low value even at the very lowest currents. A combination which has given very satisfactory performance in this application is a graphite brush operating on a carbon or graphite ring.

A very special oxide-free contact was produced several years ago by operating brass rings with graphite brushes in an atmosphere of hydrogen and mercury vapor. The hydrogen (commercial) reduced the rate of oxidation of the rings; and after a few minutes operation, aided by the slight abrasion of the brush, the mercury was able to amalgamate the small areas of the ring at which the brush was making contact. By this process the effect of the oxide was removed from the contact, and it operated as an oxide-free contact. It was possible with this arrangement to carry a current density in the graphite brushes of 100 amp. per sq. in. with a contact drop of only 0.1 v. The low contact drop of such an arrangement coupled with the desirability of the linear volt-ampere characteristic should make it especially applicable as a current-collecting device.

Future Trend

One application of sliding contacts is for the collection of heavy currents from slip rings. In this application it is desirable to be able to carry a high current density and at the same time be assured of long brush and ring life. The metal graphite brush used today has the ability to carry high current densities but is often far from satisfactory as regards brush and ring life. The same current density could be carried by a good graphite brush operating on an oxide-free ring. The advantages of such a combination are obvious. The contact-drop will be just as low as with the metal-graphite brush, whereas the ring and brush life should be much better. Furthermore the linear relation between current and voltage drop will insure equal current division between brushes operating in parallel. Thus it seems probable that in the future, a great effort will be made to develop oxide-free contacts for collecting high currents.

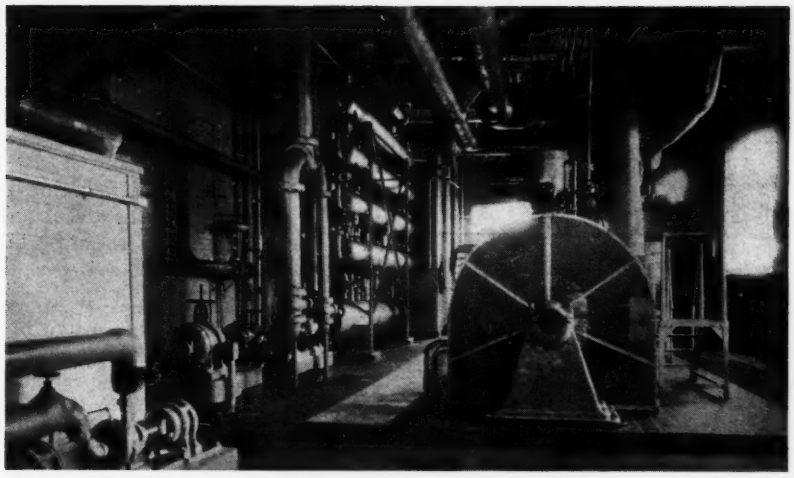
The other principle application of sliding contacts is on commutator machines, where the brush must exert a certain corrective effect in the armature coils undergoing commutation. The high contact drop of an oxide-containing contact, it has been generally felt, is essential in this application for satisfactory performance. Whether this conclusion is true or not is at present not known and can be determined only by trial. It could be readily tried by constructing a commutator from carbon. It would be interesting to know if a machine operating with the inherently low contact drop of carbon on carbon would commutate the current as well as the high-resistance contact on a copper commutator. As is well known, the copper-graphite brush with its low contact drop will not commutate a direct-current machine, but here the conditions are entirely different. In this case the specific resistivity of the brush material is low. The conclusion is that the carbon commutator would perform very well.

Air Conditioning and its effect on improving health and reducing employee lost time has been made the subject of an extensive investigation by the Industrial Sales Department of the Philadelphia Electric Co. From studies made of offices before and after the installation of air conditioning equipment and in some cases by comparing conditions from air conditioned offices with average conditions it was determined that air conditioned offices showed an average decrease in lost time of around 50 per cent.

Evaluated at five dollars a day the saving was estimated to represent $11.90 per employee, equal to approximately one-half the average owning and operating cost of an air conditioning system of about $24 per employee per year. These costs of installation and operation were estimated for an office of about 6000 sq. ft. and based on 75 sq. ft. per person. The interest and depreciation charge and the operating cost are about evenly divided, the total amounting to about $0.32 per sq. ft. per yr.

Analyses of lost time show that about 75 per cent of the total absence from work is due to colds, coughs and grip which are largely eliminated after the cause is removed by air conditioning. It is also helpful in all diseases of the respiratory system, especially with hay fever and pollen-asthma.

Another important advantage of air conditioning lies in the decreased labor turn over during the summer. A study made in a Philadelphia cigar manufacturing plant showed air conditioning reduced the labor turn over by 100 girls during the hot season, thus materially decreasing training expenses. Furthermore, a normal decrease of about 10 per cent in production per machine was eliminated and the normal lost time of 50 girls per day for a 75 day period was reduced to five girls per day for a 75 day period.



Modern Refrigeration in plants uses electric drive and the engineer must pay particular attention to machine and motor characteristics in order to get the best service from both

Refrigeration Machinery Motor Drives *and* Control

Motor Design Has Kept Pace with Refrigeration Plant Progress and the Author Shows the N.A.P.R.E. Why It Behooves the Engineer to Give Close Attention to the Machine and Motor Characteristics.
By R. C. Allen, General Engineer, Westinghouse Elec. & Mfg. Co.

IN THE OLDEN DAYS a motor was just a motor. It drove a lineshaft and belting or other simple drive and the starter was a simple switch. No particular thought was paid to starting torques, starting current limitations, efficiency or power factor. Just get the motor running and let it pull the load. One often hears old timers remark on how these motors would take abuse. One wouldn't, however, consider buying a motor of that design today. It would cost too much, not only in the way of horsepower rating, but, in the amount of power consumed for the load delivered because of poor efficiency and the penalty for low power factor.

Overload capacity of these motors was a matter of copper and iron. Given the same weight of each today and the designer gives a motor that will do even more in pulling a load than the old motor ever thought of doing and do it at an efficiency and power factor only dreamed about by the old designer.

A refrigerating plant designed today is not the same as a few years ago either and requirements for compressor, agitator, pump and blower drive have each become an individual motor drive with more specific and exacting requirements than most people realize. The motor manufacturer appreciates this and in turn attempts to offer a motor and control with characteristics that efficiently meet the requirements for each drive. These and other requirements have resulted in the necessity of an innumerable variety of motors and control for the whole field of electric drive, but, it presupposes that care will be exercised in the selection of the drive. A wrong choice more than offsets the gain to be had by new type motors.

It is therefore desirable that in the study of refrigeration and refrigerating equipment some thought be given to the characteristics of motor drives and their correct application so that the right selection be made. To do this intelligently you must know the following:

Driven machine: Horsepower at rated capacity; full load speed; starting torque required; reduced capacity conditions; effect of the above on torques.

Power current: Volts, phase and cycles available; starting current allowed; possible voltage variations.

Motor: Normal or full load rating; starting and pull-out torque; starting current; continuous or intermittent operation; special enclosures or impregnation.

Control: Magnetic or manual; full voltage or reduced voltage starting; hand or full automatic; continuous or variable speed.

Choice for most of the above may be self evident but one of the most important is not so evident. That is the torque requirements. The starting torque of the centrifugal pump and that of the reciprocating compressor are entirely different and require different types of motors.

Torque is the turning effort required to revolve or turn over the unit and is generally given in the equivalent terms of pounds pull at 1 ft. radius. Starting torque is the force required at the time of starting or the first few revolutions. It includes the "breakaway" torque and any load torque that may exist

during the first few revolutions. Load torque is the force required to handle the load at the particular speed being considered. While the unit is accelerating there is a friction torque and a load torque for every particular revolution. Full load torque is of course the torque at full load speed.

Accelerating torque is that available for accelerating the unit, the amount in excess of the load torque at a particular speed. If the torque delivered by the motor is not in excess of the torque of the load for that particular speed the unit cannot accelerate above that speed point. The greater the accelerating or excess torque the faster the unit will be accelerated to full speed where again the load torque is just the same as the motor torque delivered.

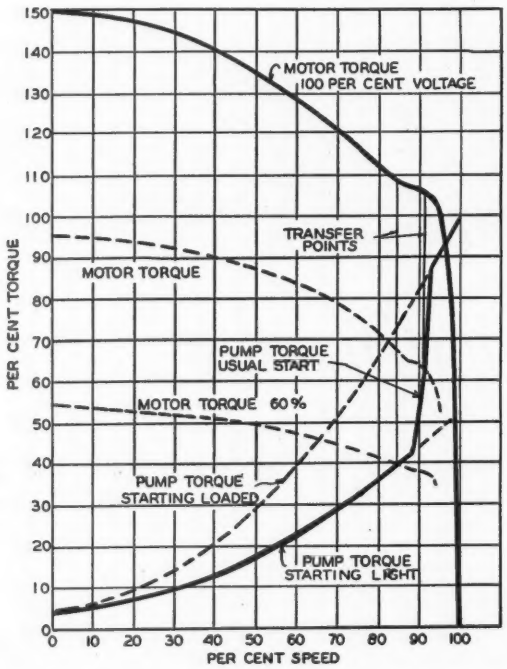


Fig. 1. Torque variation of a centrifugal pump and on the same chart synchronous motor torque at 60, 80 and 100 per cent voltage

This will be clearer by considering the curves of the driven unit and the driving motor. Figure 1 is that of the centrifugal pump starting up from rest to full speed where the torque, (except for friction) increases as the square of the speed. It will be seen that the load torque at start, due to friction is shown as about 5 per cent of the full load torque. The actual starting torque value depends upon local conditions and might be even 50 per cent on a small pump and frozen packing, a condition that might exist after a protracted shut-down.

Curves are shown for starting up with the discharge valve open (called starting loaded) and for the valve closed (called starting unloaded) and also for the probable starting conditions where the check valve in the discharge line does not open until about 85 per cent speed because it is held closed by the system pressure on the outside. It will be noted that the load torque during acceleration is never greater than the full load torque.

Torque of a refrigerating compressor starting under loaded conditions is however entirely different as is indicated by the curve Fig. 2. This is for a small single cylinder, single acting ammonia compressor starting up under full pressure, a condition which might exist if the compressor restarted immediately after shutdown due to voltage failure. The starting torque is found to be about 240 per cent of the motor full load torque. As the compressor accelerates the flywheel becomes effective and the peaks due to compression are reduced.

For unloaded conditions, the starting torque is considerably less, and even if the load is gradually applied the torque requirements are for less than when started loaded as is indicated by the curve Fig. 3. For larger compressors or with more cylinders the starting and accelerating torques would be less in proportion for both loaded and unloaded starting conditions.

It is evident that the motor driving a compressor must have considerably more starting and accelerating torque than for the centrifugal pump. Determination of the type of motor to select for these drives is therefore important and the following general classes are available:

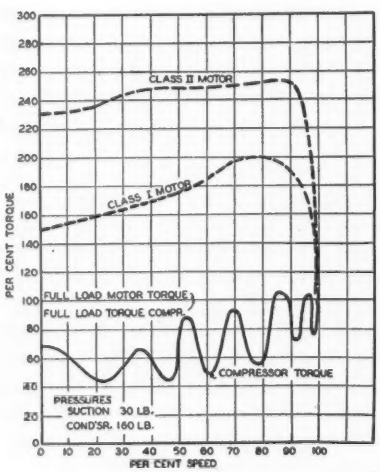
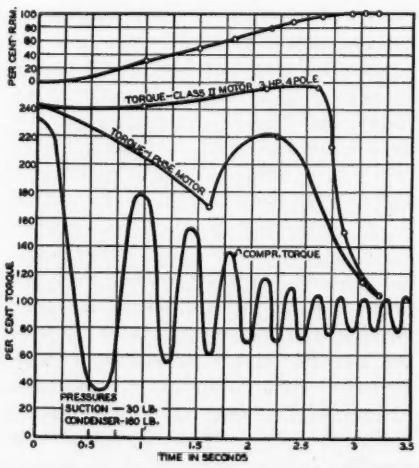


Fig. 2. (Left) Torque of an ammonia compressor starting under load

Fig. 3. (Right) Torque of an ammonia compressor starting unloaded



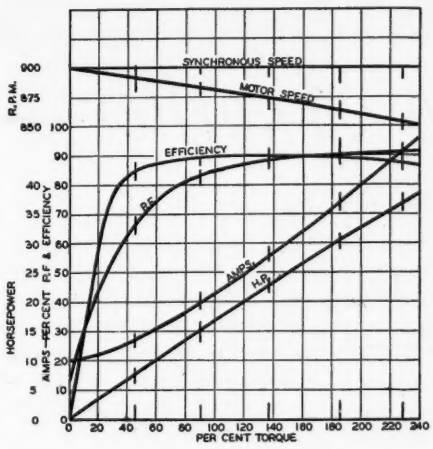


Fig. 4. (Left) Characteristic curve for a general service full voltage starting motor, Class I linestart, 30 hp., 860 r.p.m., 220 v.

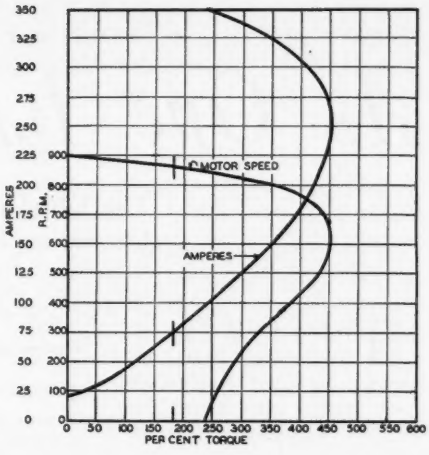


Fig. 5. (Right) An extension of the speed curves of the motor shown by Fig. 4

For alternating current: the squirrel cage motor; the slip ring or wound rotor motor; the synchronous motor for large pumps or compressors; the single phase motor for small pumps and compressors.

For direct current: the shunt wound motor; the compound wound motor.

Manufacturer's performance information on an a.c. motor includes the efficiency and power factor for ½, ¾ and full load, the starting and pull-out torques, full load current for the motor voltage and phase rating and the full load speed. The type of test curves from which this information is taken is shown by Fig. 4. The starting and pull-out torques are given on a basis of full load torque rather than in actual foot pounds for ease in making comparisons.

At the bottom of this figure, as the abscissae, is the torque scale. The curves are based on torque rather than on horsepower to represent the starting torque on the same scale. As will be indicated later, this cannot be adequately represented in horsepower because, at start and zero speed, there is zero horsepower yet anything but zero torque. The points for each quarter load on the various curves are indicated by the vertical lines.

The horsepower curve is a straight line (practically) increasing in proportion to the product of the speed and torque and the ampere, efficiency, and power factor curves are as determined by test. In general the motor is designed for maximum efficiency between ¾ and full load as this is the expected point of motor load. Efficiency and power factor start to fall off rapidly at ½ load which is the reason for poor plant power factor and efficiency where drives are over motored.

At the top the speed-torque curve shows the motor speed dropping off slightly as the load torque is increased from zero, which would be when running idle. The drop in speed is called the slip in speed or simply the slip, and is an inherent feature of induction motor operation. At no load the speed is practically the synchronous speed while at full load the speed is a little less, by the amount of the slip which is generally from 3 to 4 per cent of the synchronous speed.

If the load on the motor is gradually increased, the motor becomes overloaded and the slip increases to set up the internal electrical forces to develop the necessary torque to pull the load. Finally the increase in load would be more than the motor could handle and the motor would stall or pull out of step. Even when stalled the motor is developing a torque and this torque is the same as when first started by throwing the motor directly on the line. Curves Fig. 5 is the extension of the speed curve shown in Fig. 4.

When started, the torque developed is that shown for zero speed and as the unit accelerates the torque delivered to the drive is that shown on the curve for corresponding speed points. The motor delivers this torque independently of the load and any excess torque goes to accelerate the load. The greater the excess torque the quicker the acceleration.

Starting Torque and Starting Current

If for any reason the motor torque is not in excess of the load torque the unit will not accelerate beyond that speed point. This is really the condition at full speed and also for such drives as fans when operated at reduced speed points. This will be explained in more detail later when discussing the slip ring motor.

The corresponding increase in current is also shown on this curve and the peak, called locked rotor current, is the current drawn from the line when the motor is started full voltage, that is started by applying rated or line voltage to the motor. It is seldom possible to measure this current with the ordinary meter, under actual starting conditions, so the power company inspectors generally use a free rotor current value as the basis of their acceptance tests of an installation. This is essentially 75 per cent of the locked rotor starting current value and in securing allowable starting current for an installation it is necessary to determine if it is on the free rotor or locked rotor basis and whether it is the only motor on the premises or part of a large plant.

Starting current is to a great extent tied up with starting torque. A high starting torque means a high starting current. The starting current, as well as the starting torque, can be reduced by using a reduced voltage starter, or to a limited extent by special design.

(To be Concluded)

As One Engineer to Another—

The Chief requires information on Efficiency. His Friend explains it to him, simply and clearly.

By G. F. WETZEL

"HELLO CHIEF." At my greeting, my friend the operating engineer looked up from his desk, a somewhat worried look giving place to a smile as he answered, "Hello, G. F., I'm glad you stopped in. Perhaps you can give me a little help." "Will if I can, Chief, you know that. What is on your mind?", I replied.

"You see, it's this way," he started with his story, "Some chap got to the Big Boy in the front office and tried to sell him some gadget that he claims will save 10 per cent of our fuel bill, by increasing our boiler efficiency. Then the Boss came to me, and wanted to know what our operating efficiency is. I keep coal records and steam records, but I haven't figured out the efficiency. Just between you and me," he lowered his voice, "I don't believe I could, at least not without some strenuous brushing up,—and that is where you come in."

"Now look here, Chief," I said with pretended severity, "You are just like thousands of other good operating men,—you know your plant from A to Z,—keep everything spic and span, keep bearings tight, valves adjusted, packing tight, and turn out the steam and power the rest of the departments need, and seldom if ever stop to think of what, scientifically speaking, you are doing. At one time you probably knew your heat quantities, steam tables, and steam laws to a certain extent, and then let yourself get as rusty as an old pocket knife that has been lost in the woods. Do you ever stop to visualize, for example, what is happening in your boilers right now, and all the time they are in use? Can you picture the feed water with its load of B.t.u.s, called heat of the liquid of the feed water, going into the boiler,—getting the balance of the heat units to bring it to the boiling point,—soaking up the latent heat of evaporation,—then going out to the various steam users, giving up some of the heat for heating purposes, some being converted into mechanical energy, electrical energy, light energy,—finally being condensed, bringing back some of the original heat of the liquid, and starting the cycle over again?"

"Some of that sounds vaguely familiar, G. F., and I guess you are right. That way of looking at it does make it more interesting. So as long as you are here, and in that mood, let's go into this efficiency question right now."

"Okay. Now, just what is meant by 'Efficiency'?"

"Well, it means how good a boiler or pump or motor is."

"Now, Chief, you know an answer like that won't give your Boss the information he wants. So listen, and ask questions when you want to.

"Efficiency is a ratio,—the ratio of output to input, usually expressed as a percentage. This of course implies that you know how to figure the output and input. You are interested this time in boiler efficiency, so we will confine ourselves to that kind of efficiency. Remember, once more,—efficiency is the ratio of output to input. The next thing is to measure or put a value on,—output and input.

"When it comes to evaluating output and input we get into algebraic expressions. Most practical men are scared stiff of formulas. But just remember that formulas are not mysterious combinations of letters and figures designed for college professors to play with, but (with the exception of empirical formulas), are merely a short method of showing values and relationships on a common sense, rational basis. For convenience, letters are used in place of words, and the application of simple rules of algebra will enable you to handle most of the formulas and equations you will have to deal with, easily.

"Now, let us do a little analyzing. What is the output of your boilers? Steam, of course.

"What is the input? Coal. It might be oil or gas.

"But you cannot compare steam with coal, so we must go a step further. In terms of energy, what is the output? Heat! the heat in the steam. In the same way we can logically say that the input is heat,—the heat released by the combustion of the coal. Now that output and input are expressed in the same kind of terms, heat, we can compare them and get the ratio previously mentioned."

Here the Chief interposed a question,—"But how do you compare heat with heat? Seems to me you are just talking generalities."

"Let me ask you this, Chief," I replied, "When you come to a stairway do you make one big jump from floor to floor, or do you go up one step at a time?"

IN a series of articles, Mr. Wetzel, who has, for several years, conducted large classes for operating engineers, will take up power plant problems and their solution, as they have been brought to him from the plant by his students. He will be glad to take up any problem which any of Power Plant Engineering readers wish to submit, as to either operation of machinery or solving plant calculations. Also to have any questions or comment on methods that he has given of handling problems. Readers are invited to write him, care of Power Plant Engineering, 53 W. Jackson Blvd., Chicago, Ill., in regard to any subject in which they are interested or wish help.

"I get you, G. F., tell it your way. I'm listening," said the Chief.

"Okay. To continue, we will base our heat quantities on one pound of coal, the input being the calorific value of the coal and the output being the heat added to the steam by the boiler, (considering the boiler, furnace and grate as a unit for the present) for each pound of coal fired.

"Please notice that I said *heat added* to the steam rather than *in* the steam, and for a very important reason. We must measure the heat that we have in the steam *above* the heat we have to start with,—that is the heat in the feedwater. In other words, the boiler starts with the heat in the feedwater and *adds* the heat necessary to bring the water to the boiling point corresponding to the pressure, plus the latent heat of evaporation, plus the heat due to superheat, if any, although I know you do not superheat your steam. This is equivalent to saying that the heat added is the 'total heat' of the steam minus the 'heat of the liquid' or 'sensible heat' of the feedwater.

"Here is a diagram, Fig. 1, that will help you to see this point and remember it. You recall that all steam heat-measurements begin at freezing point, 32 deg. F. The area marked q_2 represents the heat of the liquid of the feedwater. As you can see from the diagram, H_1 equals r_1 plus q_1 and the heat added to each pound of steam could be expressed thus, $(H_1 - q_2)$, represented by distance marked Z. H_1 is the total heat of the steam, r_1 is the latent heat of evaporation, and q_1 is the heat of the liquid of the steam. These are the letters usually used to represent these quantities, the small number below and to the right of each symbol representing the different heat, temperature, or pressure conditions, such as, for example, live steam conditions, exhaust steam conditions, feedwater values. So we use the same letters with a subnumber to tell them apart. Now if we use the letter w as shorthand to represent weight of water evaporated per pound of coal, and placed it in front of $(H_1 - q_2)$ like this, $w\ (H_1 - q_2)$, we can read it in these words: Pounds of water evaporated per pound of coal, multiplied by the heat added to each pound of steam by the boiler. So tell me, Chief,—what would that give us?"

"Why, that would be,—er, uh, that is,—!", the Chief could not quite put it in words, so I helped with these questions,—"Would it be a heat quantity that had anything to do with a pound of coal? What are we trying to work out?"

"Taking the last question first,"—the Chief was thinking carefully this time, "we are working out the efficiency which is the ratio of output to input; and now to answer the first question, the heat quantity is the output from the boiler for each pound of coal fired. Now, to save you the trouble of asking me what the input is, I'll tell you that it must be the heat in one pound of coal."

"Right, Chief," I said, much pleased at the way he was reasoning out the problem. "The calorific value of the coal is the input, and usually is represented by H_f, H standing for heat, and the sub f to indicate it is the heat of the fuel, and to distinguish it from the heat of the steam.

"Now let us use E to stand for efficiency, and see what we get. The output is $w\ (H_1 - q_2)$ and the input is H_f. E as you told me is the ratio of the two, or

$$E = \frac{w\ (H_1 - q_2)}{H_f}$$

and we have a perfectly good formula for boiler efficiency."

"G. F., I salute you," said the Chief. "For the first time in my life I really see a formula clearly. It certainly is simple and understandable when it is built up as we did. But now that we have it what do we do with it?"

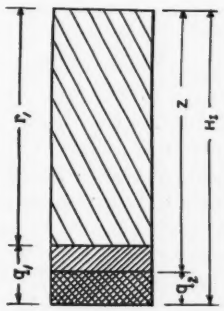


FIG. 1

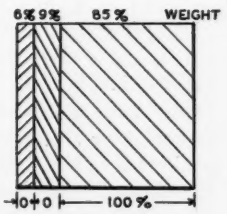


FIG. 2

"Your logical mind could answer that by itself if it was not so lazy," I told him. "But if you insist on spoiling your own fun, I will suggest that, to evaluate the letters of the formula, you simply put in figures which you know or can easily obtain, and then solve for the unknown quantity E. Look in that hand book on the shelf behind you, and find the steam tables. Take a piece of paper and write down these items as I mention them, and put after each one its value. From the known conditions with the help of the steam tables you can find all the figures. And please note that most steam tables give pressures in pounds per square inch absolute, which means 14.7 lb. more than gage pressures. If you call it 15 lb. it will usually be close enough for all practical purposes. Remember gage pressures are measured above atmospheric pressure, while absolute pressures are above zero pressure or a perfect vacuum. This is an important point to watch because wrong pressures will give wrong heat values, and of course your answer will not be correct."

After naming the pertinent data, and giving him time to put in the figures, he handed me the paper with the following:

Steam pressure—150 lb. ga. or 165 lb. abs.
Feedwater temperature—160 deg. F.
Total heat in steam, H_1—1195.0 B.t.u.
Heat of the liquid in feedwater, q_2—127.9 B.t.u.
Calorific value of fuel, H_f—11,500 B.t.u.
Water evaporated per lb. coal—w, 7.3 lb.

$$E = \frac{7.3\ (1195.0 - 127.9)}{11{,}500} = 0.678 \text{ or } 67.8 \text{ per cent.}$$

"Now I can talk to the Boss and tell him our efficiency," the Chief exclaimed with a certain amount of

justifiable pride. But I asked him, "What will you tell him if he asks for the evaporation per pound of combustible burned, or per pound of coal burned? What you have just found is the efficiency of boiler and furnace for the coal as fired, or the over-all efficiency of the furnace as a combustion device and the boiler as a heat absorbing device, combined."

The Chief's jaw dropped as he exclaimed, "You would pull something like that! But I must admit, G. F., that you are right,—and what *will* I tell the Boss if he brings that up as he is very liable to do?"

"You will simply tell him that, since your coal has 6 per cent moisture and 9 per cent ash, the evaporation per pound of combustible fired is,

$$\frac{100 \times 7.3}{100-(6+9)} \quad \text{or} \quad \frac{100}{85} \times 7.3 \text{ or } 8.6 \text{ lb.}$$

"Sure, that is simple," agreed the Chief. "But why do you get at it that way?"

"Many times a diagram will help to make clear problems of this kind, so look at this sketch, Fig 2, representing a pound of coal. When you fire that pound of coal, you actually burn only 0.85 of a pound which is all that is actually burnable, since, of course, you cannot burn the moisture or ash. Therefore, you burn 0.85 lb. of combustible and evaporate 7.3 lb. of water. If you burned a whole pound of combustible, you would, of course, evaporate $100/85 \times 7.3$ lb. This would be the evaporation for each pound of combustible that goes onto your grates. But suppose you lost 2 per cent of your coal through the grates, then your evaporation per pound of combustible burned would be $100/98 \times 100/85 \times 7.3$ because only 98 per cent of each pound was actually burned."

"By George," came from the Chief, "I certainly appreciate your bringing out these points. I guess I can talk intelligently to the Boss now."

"Just a few more thoughts, Chief, and then I'll be going. Remember that there are two distinct parts to steam generation: (1) the combustion equipment whose efficiency is checked by flue gas analysis; and (2) the boiler or heat absorbing equipment. The efficiency we have gone over is the over-all result measured by comparing the heat gained from the boiler by the steam sent out, with the heat it is possible to get out of the combustion of your fuel. We will consider furnace and combustion efficiency at some future time.

"Also this,—the kind of work we have discussed just now has several points of value,—it will give you a fundamental basis for improving power plant operation,—it will help you to pass fairly and intelligently on the merits of new equipment,—and will give you a broader and more interesting viewpoint of your work. Well, I'm on my way. Good-bye, Chief."

NEW SEAPLANES, Sikorsky S-42, have been tested out and will soon be in use by Pan American Airways to cut 2 days time from the run between Miami, Fla., and Buenos Aires, S. A. The tests with load of 32 passengers and 2000 lb. of mail and express showed 157.5 mi. per hr. over 1244 mi., using only 69 per cent of the 3000 hp. of the 4 Pratt & Whitney Hornet Engines.

Capital Goods Opportunites

IN AN effort to determine an accurate basis for computing the volume of "pent-up" orders for equipment and capital goods, the Machinery and Allied Products Institute has inaugurated a survey of plant replacements and additions for which need has accumulated during the five depression years since 1929. It covers a fairly large number of representative companies in capital goods industries and coöperation of other national trade organizations is being enlisted, including farm and electrical machinery, fabricated metal and graphic arts, to broaden the basis for measuring the delayed demand.

Of the several hundred reports received, some 95 per cent state that replacements will be made as soon as it is clear that business confidence has been restored and credit reëstablished, estimates for individual plants ranging from a few thousand dollars to several hundred thousand and, in the case of one company as high as $2,000,000. These returns thus disclose a large amount of business waiting, to be translated into orders, only clear probability of satisfactory, settled business conditions, the amount of prospective demand being indicated as in the nature of tens of billions of dollars. Up to 1930 some $8,000,000,000 of new machinery was bought annually. It has declined to $2,000,000,000, a deficit of some $3,000,000,000 a year average, over a period of 4 yr. Worn out, obsolete and shut down plants will require machinery replacement, covering machine tools, power equipment and transmission line material and process machinery.

Renewed confidence is felt to be the main requirement for releasing activity but other factors will be credit available for making needed purchases and governmental policy as to taxes and new legislation.

The Institute is desirous of having from as many plants and companies as possible reports on their probable requirements, when sound governmental policy and restored confidence are evident, covering for machine tools, electrical equipment, power plants, and service equipment, a description of machinery required, whether for replacement or additions and the estimated cost. In case it is not desired to sign the company name, the nature of the industry may be indicated.

Data submitted will be held as confidential by the Institute and used only in making up the summary of the survey. It should be sent to Machinery and Allied Products Institute, 815 15th St., Washington, D. C. The coöperation will be appreciated and the result of the survey should give a decided impetus to capital goods industries.

WHEN A SINE wave voltage of rated value and frequency is impressed on a single phase transformer, the exciting current wave will be distorted, the amount of distortion being determined by the flux density in the transformer core. The third is the most prominent harmonic in the current wave.

Underfeed Combustion

As Affected by Fuel Size and Air Temperature

Investigation of Combustion and Combustion Conditions Shows that Air Temperature, Type of Fuel and Size of Fuel Determines the Rate of Burning. By P. Nicholls*

PREVIOUS RESEARCH by the Bureau of Mines has been on the overfeed type fuel bed, a general designation that includes hand-firing; moreover, the air used for combustion has been at normal temperatures of about 80 deg. F. The present work covered studies of the underfeed-type fuel bed, exemplified by underfeed stokers, and of the effect of preheated air on what transpires in fuel beds.

The tests of underfeed burning were made in a 20-in. diam. refractory-lined fireport. The underfeed burning was obtained by filling the firepot and igniting at the top, giving unrestricted ignition; that is, the plane of ignition could advance downward as fast as it was able with the constant rate of air supply used in each test. The quantity of fuel burned was also free to be whatever the fuel could do with the rate of air supply. It is evident that if the rate of ignition, expressed in pounds per square foot per hour, was greater than the rate of burning in the same units, the thickness of the live fuel fed would increase gradually. If with some thickness of live fuel bed the rate of burning becomes equal to the rate of ignition, the burning would be in equilibrium, and a fuel bed of constant thickness would travel down until the plane of ignition reached the grates.

The variables investigated were: Kind and size of fuel, rate of air supply, and temperature of air supply —that is, preheat. The fuels used were high-temperature coke, low-temperature coke, petroleum coke, three anthracites, Illinois coal, Pittsburgh coal, and splint

*Supervising Engineer, Fuels Section, Pittsburgh Experiment Station, Bureau of Mines. Taken from Bulletin 378.

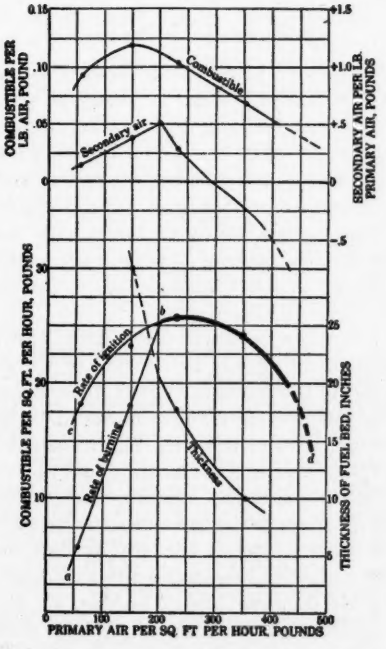

COMBUSTIBLE PER LB. AIR, POUND
SECONDARY AIR PER LB. PRIMARY AIR, POUNDS
Combustible
Secondary air
Rate of ignition
Rate of burning
Thickness
COMBUSTIBLE PER SQ. FT. PER HOUR, POUNDS
THICKNESS OF FUEL BED, INCHES
PRIMARY AIR PER SQ. FT. PER HOUR, POUNDS

Fig. 1. Data as plotted for 1½ to 2 in. high temperature coke

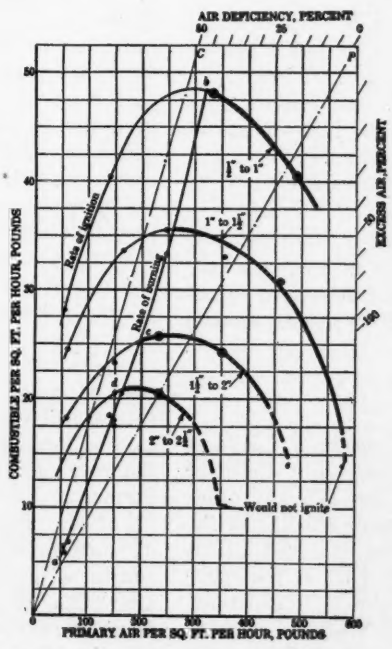


Fig. 2. Size of fuel affects the combustion rate materially

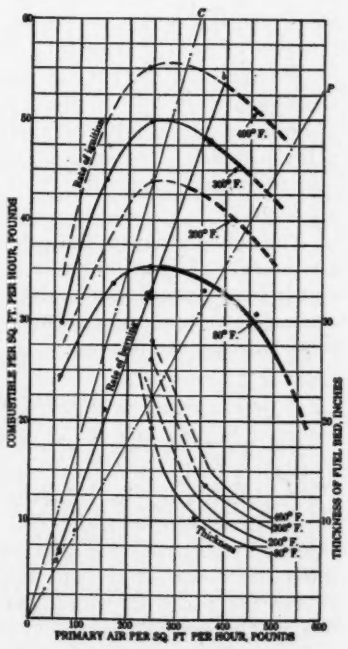


Fig. 3. Rising temperatures also increase the combustion

coal. The first four represent noncaking fuels, the Illinois is moderately caking, the Pittsburgh heavy-caking, and the splint a tar-exuding coal.

In spite of the fact that coke has limited application in service, high-temperature coke was used for the first, and most complete, set of tests of underfeed burning. Coke is the most convenient fuel to use in investigating principles of burning because it eliminates the uncertainty of size of pieces when one has to break up a caked or coked fuel, because the bed does not have to be disturbed by poking, and because the cost of the tests is reduced very much in that the gas analyses can be made much more quickly.

Coke Tests

Figure 1 shows plots of the data for 1½ to 2-in. coke. The abscissa is pounds of dry air per hour per square foot of grate surface. The left ordinate scale is pounds of combustible (carbon + hydrogen) per hour per square foot of grate surface. The test points are shown, and the curves beyond the range of the points are dotted. The two main plots are the rate of ignition and the rate of burning of combustible. The light-line portion—cb—of the ignition curve means that it is for ignition only; the heavy-line portion—bd—means that it is part of both the ignition and the rate-of-burning curves. The rate-of-burning curve is thus abd.

Considering these two curves, they show that at 100 lb. air rate the rate of ignition is about 21.5 lb. per sq. ft. per hr. but that the rate of burning is only 12 lb.; therefore the coke at the bottom of the burning zone is being ignited at a faster rate than the coke above it is burning (being gasified), and consequently the thickness of the burning zone is increasing continually. At an air rate of about 200 lb. the rate of burning is the same as the rate of ignition, so that the live fuel bed will maintain constant thickness. At air rates greater than 200 lb. the rate of burning could increase along a continuation of line ab, but it cannot be greater than the rate at which the fuel is ignited, consequently it does the best it can and follows rate-of-ignition curve bd which—for this fuel—increases a little at first, reaches a maximum at 250 lb. of air, and then decreases with further increase of rate of air supply.

The ignition curve indicates that at high rates of air the rate of ignition tends rapidly to approach zero and it was impossible to maintain burning; such occurrences are a common experience and are usually spoken of as blowing the fire out.

Air Rates

One curve in Fig. 1 shows the observed thickness of the live fuel bed. This thickness includes the clinker and unfused ash; the values given for this and other curves for thickness which follow were selected in the same manner from the plots of the observed values during the entire test. The full-line part of the curve covers the range in which the thickness is constant; one would expect the observed thickness to increase with time because of the accumulation of clinker, but the increase was usually small compared with individual variations due to the method of observation.

The dotted part of the curve covers the range in which the thickness is increasing; the height of the bed when the ignition plane reached the grates is used for the thickness in this range. The two upper curves of Fig. 1 show the pounds of combustible in the flue gas per pound of air supplied and the pounds of secondary air required for perfect combustion per pound of primary air. The secondary air curve shows that secondary air would be required up to a primary air rate of 280 lb.

Foregoing results and the interpretations relate to the condition of unrestricted ignition. Commercial underfeed stokers have restricted ignition in the sense that the rate at which the stream of fresh fuel passes into the primary air stream can be controlled.

Fig. 2 shows the rate-of-ignition and rate-of-burning curves for the four sizes of coke air at 80 deg.; the test points are shown, and it will be noted that fairly symmetrical curves can be drawn to fit the points. It is of interest that the rate-of-burning curves, before their intersection with their individual rate-of-ignition curves, all fall on a common curve which bends upward slightly for the smaller sizes, as would be expected from previous investigations of the effect of size in overfeed burning. The figure shows that the rate of ignition increases rapidly with decrease in size, which agrees with common experience.

Preheated Air

If the air rates were carried high enough all the ignition curves may be expected to have a shape like that of the 2- to 2½-in. size. An attempt was made to burn this size at an air rate of 345 lb. There was difficulty in getting the fuel to start burning; by using larger quantities of igniting fuel and reducing the air rate it was ignited, but when the air rate was increased to the 345 lb. the burning gradually decreased and finally the fire was extinguished, showing that ignition could not be maintained.

In the tests on effect of preheat, air temperatures used were 80, 200, 300, and 400 deg. F. There was no necessity to test all sizes because the characteristics will be similar; therefore only the 1- to 1½-in. coke was used. Figure 3 shows the results; lines OC and OP have the same meaning as in Fig. 2. The parts of the rate-of-combustion curves falling on line ab are not affected materially by the preheat; because the same size of coke is used, ab has not an upward bend and is closely a straight line to the origin.

Figure 3 shows that preheat will have little effect on operation at rates of air supply below that at which the ignition curve meets the burning curve; it increases the rate of ignition but does not affect materially the rate of burning, which is the limiting factor. Above the rate of air supply where the ignition curve for normal air temperature meets the burning curve (265 lb. of air) preheat permits large increase in the rate of burning with a given rate of air supply but, of course, with the necessity of increasing the secondary air. Thus, with an air temperature of 80 deg. F., the maximum rate of equilibrium burning was 35.5 lb. with 265 lb. of air; and, as pointed out previously, no manipulation of the fuel bed, other than increasing

the area of the ignition surface, could increase this rate. With an air temperature of 400 deg. the maximum rate of burning would be about 53.5 lb. with 390 lb. of air.

The lower set of curves of Fig. 3 shows the thickness of the live fuel beds, for which, however, there were not many test points. The full-line portion indicates that the burning is in equilibrium. The fact that for the same rate of air supply the thickness increases with increase in temperature of the air may seem an anomaly at first sight. The explanation is that the increase in the rate of burning occurring with the preheat requires a thicker fuel bed for equilibrium burning; the increase thus required is more than can be offset by the increased reaction from the preheat.

Fig. 4, A, compares the rates of ignition of all fuels for the 1- to 1½-in. size, 80 deg. F. temperature, and varying air rates; the rates of ignition are expressed as pounds of combustible per sq. ft. per hr. The portions of the curves of the bituminous coals shown dotted are below the equilibrium rate of burning. They have been swung to the left from the values obtained in the tests on the assumption that they would have the shapes shown if the bed were kept open by agitation; this makes them comparable with other fuels.

Combustion Rates

All the fuels except the petroleum and low-temperature cokes reached a maximum rate of ignition, which then fell off; it can also be assumed that, having once started to fall, the decline would have continued if the air rate had been carried higher and that there would have been a limiting rate above which it would have been impossible to maintain the burning.

Fig. 4, B, shows the rate of travel of the plane of ignition, in inches per hour, for the same fuels shown in Fig. 4, A. The scale of pounds per hour is more useful for the combustion engineer, but inches per hour is probably more logical when ignitibilities are compared because the direct effect of density on rates of ignition cannot be great; the indirect effect of density as defining the type of exposed surface is very important. The rate in inches per hour will sometimes be the more pertinent scale, even in service—for example, in the tendency of fuels to ignite down through pot-type stokers.

At low rate of air supply the rate of ignition was greater than the rate of burning; thus the fuel bed did not reach an equilibrium thickness. Under this condition the rate of ignition did not limit the rate of burning.

Each fuel reached equilibrium at a certain air rate; and for all higher rates the fuel bed would be in equilibrium, its thickness decreasing with increase in air rate.

Rate of ignition did not increase indefinitely with increase of air rate. For the high-temperature coke and anthracite it reached a maximum and then decreases rapidly; for the other fuels it reached a maximum and tended to decrease more slowly.

Rate of ignition, and consequently the maximum rate of burning attained, increased with decrease in the size of fuel.

Preheating increased the rate of ignition of all fuels very materially at all air rates; thus with the Illinois coal an increase from 80 to 300 deg. increased the rate of ignition and the possible maximum rate of burning 97 per cent.

These results bring out the essential difference in the principles of overfeed and underfeed burning. In the overfeed the only limit to the rate of burning is

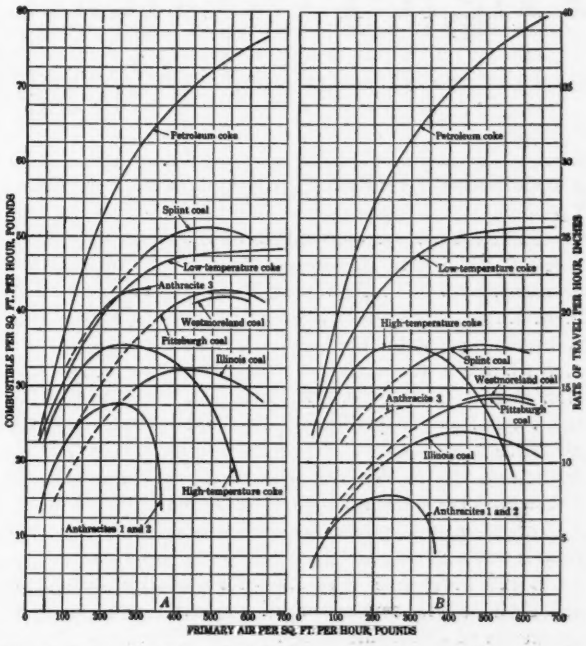


Fig. 4. Rate of ignition of all fuels compared on pounds per square foot and inches per hour basis

that the fuel shall not be blown out of the bed, and—except for the limitations imposed by loss of heat from the fuel bed by radiation—by increasing the depth of the bed the combustible gasified per pound of air can be made the maximum the air will carry. In the underfeed the maximum rate of burning for each rate of air supply is fixed by the rate of ignition, and these two factors automatically fix the thickness of the fuel bed and the combustible carried per pound of air.

Studies were also made of the process of ignition and of burning in underfeed beds, both with high-temperature coke and bituminous coal. They show that ignition is rapid when it once begins and that at high rates all the volatile matter is driven off in the first 3 in. of the live fuel bed.

An analytical study of the distribution of the ash and clinker in fuel beds shows the difference between the overfeed and underfeed methods of burning. The time it takes a piece of fuel to pass through the live bed is 4 to 5 times longer in an underfeed than in an overfeed bed of the same depth and rate of burning. Moreover, the quantity of ash and clinker which accumulates in an underfeed fuel bed is several times as great as in an overfeed bed operating under the same conditions. These test results may be and were applied to deduce what happens in simple type stokers but no attempt was made to analyze the series of complex reactions in large stokers because there are no data from which the paths of the various streams of coal can be predicted.

Power Transmission by

High-Potential Direct Current

A Revolutionary Development

DEVELOPMENT of a complete new system for the transmission and distribution of electric power, making it possible for the first time to interconnect, with static apparatus, non-synchronous systems, was announced at the A.I.E.E. meeting. This has been done by the utilization of electronic devices, including Thyratron and Phanotron tubes. With the new system a higher order of stability has been obtained as contrasted with previous practice, and faults similar to short circuits result in a reduced instead of an increased power flow on the circuit involved.

CONSTANT-CURRENT, direct-current transmission, a new system, was described in a paper presented at the winter convention of the American Institute of Electrical Engineers, in New York City in January, by Dr. C. H. Willis, B. D. Bedford, and Dr. F. R. Elder. Dr. Willis is of Princeton University but is associated with the General Electric Co. in the direct-current transmission work, and the other two men are of the General Electric Co. In addition to the formal paper presented at the Institute meeting by these three men there were discussions by C. W. Stone and Dr. A. W. Hull, also of the General Electric Co., who have been associated with the work.

Direct-current power transmission by constant current is in itself not new, but the work described represents the first time that such transmission has been accomplished in a commercial capacity, even in test, by means of electronic tubes.

In brief, the essential features of the new system of electric power transmission are:

It is a constant-current direct-current system.

It is a system where the power flow is in one direction only at the will of the operator; but the power can be transmitted in either direction if desired.

Control of the amount of power flow is under the control of the operator at all times.

No wattless power is transmitted.

A short circuit on any circuit of this type results in a reduction of power flow on the circuit involved.

Power can be transmitted by either overhead or underground lines any distance desired.

A circuit of this type can be tapped at any point to furnish power or to take power.

The nature of the circuit is such that systems of like or unlike frequencies can be operated together to feed any other system of like or unlike frequencies.

Overhead systems of this type should be more reliable, and less disturbance will be caused by lightning.

The system cannot become out of phase or out of synchronism with the system feeding it or with the system receiving power.

Difficulties Encountered With Alternating Current

Alternating current is at present almost universally used for power transmission, in spite of the difficulties that are so well known to electrical engineers. The difficulties of connecting systems, or even generating plants, together are many, as systems of unlike frequencies cannot be connected together readily except by means of motor generator sets, and the power flow through these motor generator sets is uncontrollable except by elaborate and expensive apparatus. Systems of like frequency are difficult to keep together in synchronism because of the phase angle resulting from the reactances of transformers and circuits. Control of power flow is largely determined by the demands of the system, and the operators have little control except by means of circuit breakers, which may be opened or closed, automatically or manually, usually resulting in interruption of service. This means that in case of faults anywhere on the system, a large concentration of power results, which may be sufficient to shake the system apart and cause considerable damage.

The newly developed direct-current system places in the hands of the operator full control of his system. He can at all times control not only the amount of power flow but its direction. The system cannot get out of phase or out of synchronism; and faults, such as short circuits, cause a drop in power flow rather than an increase such as exists on all present systems.

Stations of like frequency or unlike frequency can be connected together with the new system to feed the same distributing system without any trouble.

Wattless Current Eliminated

As most loads of power systems are of lagging power factor, the transmission of the resulting wattless current adversely affects the capacity of the circuits, the transformers, and the generators feeding the system. With the new system, all the load on the generating stations will be slightly leading, rather than

lagging; and no wattless power is transmitted. The wattless current required by the loads is supplied by the inverter equipment. This results in lower generator and transformer heating, and improved regulation.

Circuit for 150 kw., 15,000 v. in Experimental Service

In the paper presented by Dr. Willis, Mr. Bedford and Dr. Elder there was described a circuit installed in the research laboratory at Schenectady arranged for the transmission of 150 kw. of power, the circuit operating at a maximum peak of 15,000 v. and 10 amp. In one of the factory buildings in the Schenectady works there has been made a larger installation, referred to in the discussion at the Institute meeting, in which connection is made to a 13,800-v., 60-cycle, three-phase alternating current bus of the New York Power & Light Corp. with a circuit for transmitting a constant direct current of 200 amp. at 15,000 v. This circuit includes about 15,000 ft. of underground conductor, and is connected back to the 13,800-v. bus, after being inverted from direct to alternating current of the proper characteristics.

In this 3,000-kw. constant-current direct-current circuit, a group of condensers and reactors are so connected to the 13,800-v. bus that constant-current alternating current is obtained; the circuit being tuned so that this current is 200 amp., the voltage varies with the load. The alternating current is then rectified by means of six Phanotron tubes. (If two-way transmission is desired, Thyratron tubes are used.)

High-voltage constant-current direct current is thus produced. After passing through some direct-current smoothing reactors the current goes through the 15,000-ft. length of underground conductor—representing transmission of the energy—after which it is received and passed through another direct-current smoothing reactor. Six Thyratron tubes then invert the direct-current into 60-cycle, three-phase alternating current of constant value. Another group of reactors and condensers then changes this constant current into constant-potential alternating current, the current output at this point varying with the load. Connection is then made back to the alternating-current bus in the factory. Such an arrangement of condensers and reactors constitutes what is known as a monocyclic network.

Constant Potential Features

One feature of such a network is that, if it is tuned for a certain definite current and if it receives this current, constant potential results at the output terminals. On the other hand, if it is supplied from a constant-potential bus, constant current will be obtained at the terminals. Neglecting the losses in the reactors and condensers, the power factor on both sides of the network is equal, but of opposite value.

No transformers have been used in the installation made in the Schenectady plant, but, in a commercial installation, it is probable that transformers would be used at both ends of the line—at the sending end for increasing the voltage to that point desired, and at the receiving end for reducing the voltage to suit that of the receiving system.

The rectifier end of this network connected to a constant-potential system will furnish a sufficient voltage to cause the full-load current of the direct-current system to flow. Thus, if a short circuit of low resistance exists close to the rectifier, the voltage furnished by the rectifier will be very low—only sufficient to overcome the low resistance of the short circuit. The power flow, then, will be reduced; and. if the resistance is of very low value, the voltage will collapse to practically zero.

At the receiving end of the line, or the inverter, the tubes, being arranged to pass current in one direction only, will operate as an inverter as long as constant current is received from the rectifier. Failing to receive this constant current, the inverter becomes a rectifier and draws full-load current at low voltage from the alternating-current system to which it is connected. The polartiy of this current will be reversed, however.

Effects of Short Circuits

If a short circuit occurs on the direct-current line, and if the constant current of the system is 200 amp. and the regulation of the line is 10 per cent, then the current flow into the short circuit will be about 20 amp. The voltage on the direct-current line drops to that point necessary to cause 20 amp. to flow in the short circuit.

As soon as the short circuit is removed, normal current flows in the normal direction, the rectifier furnishes its share of the current, the inverter receives the current, and the current is inverted and furnished to the receiver system as constant-potential alternating current.

If, when the line is operating under normal conditions, the cable is short-circuited by means of a single-pole knife-blade switch, the voltmeter reading drops practically to zero but the current remains constant. If the switch is then opened, the voltage returns very promptly and at all times the current remains constant.

A further interesting demonstration is made by short-circuiting the line through a 6-amp., 250-v. cartridge fuse. The fuse blows, thus opening the short circuit; little disturbance is caused by the blowing of such a small fuse.

Insulators Serve as Lightning Arresters

In still another demonstration an insulator normally used on an 11,000-v. alternating-current line is employed. Two such insulators are usually used on such a line, but in the demonstration there is only one. If an attempt is made to arc over the insulator by short-circuiting it with a small wire, the arc-over of the insulator cannot continue. It is indicated that overhead lines can be built with fewer insulators than are now required for alternating-current power since, while they may arc over because of a lightning flash, the dynamic current of the system is limited and the arc will extinguish itself. Each insulator thus becomes a lightning arrester to clear the line of any high-voltage transients.

Case Studies in Power Economics

METER CONSTANTS

Conducted By
ZUCE KOGAN
Kogan Industrial Service
Chicago, Illinois

PLACES where savings can be accomplished around a power plant are usually quite numerous. The possible saving in any particular case may seem so small as to be scarcely worth the effort to investigate and put into effect, but in the aggregate the savings possible usually mount to unbelievable figures. Such savings come as a result of case studies dealing with specific equipment and conditions, and to appreciate their importance each case must be considered separately. Recognizing this fact, the editors of Power Plant Engineering have arranged with Mr. Kogan to present in serial form a number of articles relating the essential history of cases where substantial savings have been effected in the power plant field. Mr. Kogan is engaged in a consulting service and is in position to answer questions, which readers may propound, relative to savings about their plants. He is eminently fitted to conduct these pages as a savings service to readers.
Editor

AN ICE manufacturer was purchasing power from the electric utility under the so-called ice rate. This rate is a limited-hour rate. That is, the curtailment of power used between the hours of 4:30 to 7:30 p. m. in the months of November, December, January and February is required. If any power is used during that period there is a definite charge for it and it is paid for throughout the year, once it is established in any of these months.

During our study of our client's power condition we found that his peak demand, that is the demand established during the hours of 4:30 to 7:30, was exceptionally large. We could not find any possible excuse for it, as practically all of the equipment was shut down, with the exception of one small air compressor and one agitator on the brine tank. The peak demand was around 43 kw. while in reality on the meter test, the actual power use was around 32 kw.

At the time the electric utility determined the peak demand by taking the average of the three highest readings, each reading occuring during a different day, during the hours of 4:30 to 7:30, and once this highest demand was established it was charged for throughout the year.

The meter used in determining the demand was the so-called printometer, which is a device actuated by the watthour meter and it totals during every half hour the number of kilowatt hours consumed. The accumulative total is printed on a tape and, in order to determine the half-hourly demand, the difference between two consecutive numbers is taken and multiplied by the meter constant, as the numbers actually printed do not represent the number of kilowatts but a multiple of them depending on the gear ratios and the mechanism of the printometer.

Since there was such a large discrepancy between the billed demand and the actual demand, we called in the electric utility records and we found the accompanying tabulation of readings for a few days in the month of November.

The demand indicated was obtained by multiplying the difference by the constant of the meter which happened to be 14.4. After a study of this table was made it was quite easily seen why such a high peak demand was charged for, while in reality there was a much lower demand.

As stated previously the utility, in order to determine the peak demand, picks the highest readings during any day for three days and the average represents the maximum peak demand. In the table above it is seen that on some half hours the demand read about 43 kw. while the others are only about 29. This effect became quite clear to us when we took into consideration the mechanism and the working of the meter.

In order to obtain the half-hourly maximum demand, the watthour meter is equipped with a device which actuates the demand meter, the latter being controlled by a clock which causes the demand meter to print every half hour. The device which actuates the demand meter consists merely of two contact points riding over a ratchet-wheel with a definite number of teeth. This ratchet-wheel is attached to a worm-gear which is driven by a worm on the shaft of the revolving disk of the watthour meter. As the ratchet-wheel rotates with worm gear, the contact points are made to open and to close.

It is when these contact points are closed that the solenoid of the demand meter is made to move a number on the printing wheel by means of a plunger. The frequency with which the numbers will be moved will depend on the speed of the disk, on the ratio of the worm and the worm gear and on the number of teeth in the ratchet-wheel. The combination gear ratios and the number of contacts on the ratchet-wheel determine the constant of the meter and therefore each number moved means a definite number of kilowatt hours. This definite number is obtained by multiply-

ing the difference between two readings by the constant of the meter.

In such a method for determining the demand, discrepancies may creep in, as there is the effect of time limitation. The only time when a discrepancy will not creep in is when the rate of consumption is a multiple of the constant of the meter, or when readings are taken over a very long period of time. When the consumption is a multiple of the constant, the printing and the movement of a number will coincide. Therefore, the printed reading will show a true demand. In practice such things are rare and the demand is almost never a multiple of the constant of the meter.

Meter readings on which the demand for power was based

	Nov. 2			Nov. 5			Nov. 12		
	Reading	Difference	Demand	Read.	Diff.	Dem.	Read.	Diff.	Dem.
4:00 p. m.	800			611			444		
4:30 p. m.	804	4	57.6	615	4	57.6	447	3	43.2
5:00 p. m.	806	2	28.8	617	2	28.8	449	2	28.8
5:30 p. m.	809	3	43.2	619	2	28.8	451	2	28.8
6:00 p. m.	811	2	28.8	622	3	43.2	454	3	43.2
6:30 p. m.	813	2	28.8	624	2	28.8	456	2	28.8
7:00 p. m.	815	2	28.8	626	2	28.8	458	2	28.8
7:30 p. m.	817	2	28.8	628	2	28.8	460	2	28.8

When the demand is not a multiple of the constant of the meter, the ratchet-wheel will cause a definite number of contacts to be made, which will represent a demand for the first half hour less than the actual, as at the time of printing not enough movement was given to the ratchet-wheel to cause another contact. If the difference between the actual demand of the previous half-hour and the printed one is large enough so that the sum of the demand of the next half-hour and this difference is enough to move an extra number, the printed demand for this half-hour will be larger than the actual. If the difference is not large enough it will add up to any one of the following half-hours.

The readings of November 2 illustrate this.

During the half-hour of 4:00 to 4:30 the demand shown is only 57.6. In reality the demand at that time was around 68. Since, however, 14.4 goes in, 68 only four times plus a remainder of around 10 kw., which was left over to accumulate in the next half-hour. Now, as we have found out later that the actual demand was around 32 kw. the total of the remainder plus the present demand was only 42 kw., a number not sufficient to cause the rotation of another contact. Hence, the demand for the following half-hour remained 28.8 as 14.4 goes only twice into 42, leaving a remainder of 13. Hence, the demand established between the half-hour of 5:00 to 5:30 was the total of the actual demand of 32 kw. plus the remainder of 13, not recorded in the previous half-hour, or 45 kw., an amount sufficient to cause the making of three contacts and showing a demand of 43.2 kw. During subsequent half-hours the demand continued to be 32 kw. Since not enough movement was added, however, only 28.8 was shown.

The correctness of our contention was corroborated after the meter constant was changed in accordance with our recommendation. The constant was changed so that each number represented only 6 kw. instead of the previous 14.4. In the table below is shown the reading for a typical day in the month of November during which the operation of equipment was very much similar to the previous days in November.

Meter readings after the constant had been changed

Time	Read.	Diff.	Dem.
4:00 p. m.	620		
4:30 p. m.	631	11	66
5:00 p. m.	636	5	30
5:30 p. m.	641	5	30
6:00 p. m.	646	5	30
6:30 p. m.	651	5	30
7:00 p. m.	656	5	30
7:30 p. m.	662	6	36

There it was apparent that the actual demand was recorded at 4:30. The peak demand was around 31 kw. and it took about five half-hours in order to accumulate, so to speak, enough hangover so that a higher number could be printed. That is, in five half-hours, 5 kw. were accumulated in order to indicate a demand of 36 at 7:30 p. m.

We were instrumental in causing the utility to change its method of computing the peak demand, especially in cases where the peak demand represented a small portion of their customer's normal daily load. At the present time the utility, instead of picking the highest number on different days of the month, now take three consecutive high numbers per day for three days and the average of them constitutes the peak demand.

Unfired Pressure Vessel Code

In Order to Provide a uniform basis for the construction and maintenance of unfired vessels used in the petroleum industry and at the same time not to disturb the uniformity brought about by codes developed by the ASME Boiler Code Committee, a joint committee of the A.P.I. and the A.S.M.E. was organized. This Joint Committee on Unfired Pressure Vessels has now completed the first edition of the API-ASME Code for Unfired Pressure Vessels for Petroleum Liquids and Gases which can be obtained from The American Society of Mechanical Engineers, 29 West 39th Street, New York.

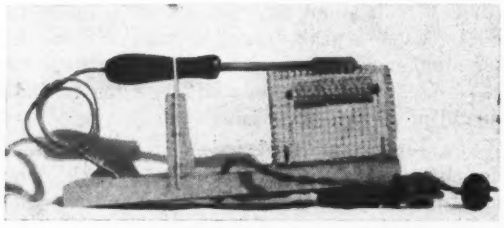
The code covers the design, construction, inspection and repair of unfired pressure vessels for petroleum liquids and gases for metal temperatures not over 1000 deg. F. and for gage pressures above 15 lb. per sq. in. It is divided into five sections as follows: W, design and construction of fusion welded vessels; R, design and construction of riveted vessels; F, design and construction of seamless forged vessels (in course of preparation); I, inspection, repair and allowable working pressure of vessels in service; S, material and other specifications.

Readers' Conference

Repairing a Midget Soldering Iron

A GOOD MANY READERS perhaps possess a burnt out electric soldering iron which they have tried to repair and have failed due to inability to easily obtain the very fine resistance wire by means of which the small irons are heated. On the contrary, most any experimenter has or can easily obtain the larger resistance wire such as is used on toasters, electric stoves, etc.

I wound as much of this larger wire into the space provided in the iron and found this was not a sufficient quantity to withstand the 110 v. current. Therefore, the rest of the wire was wound on a porcelain tube (external to the iron) and this was mounted on a board by means of two upright pieces of brass. Bolts too short to make contact inside the tube serve



View of Soldering Iron on Its Stand

to hold the tube in place and also furnish a means of fastening the ends of the resistance wire wound on the tube. Bolts which hold the brass uprights to the base enable the external resistance and soldering iron to be connected in series beneath the base.

In order not to waste all of the heat emanating from the external resistance I made a protecting cage of wire screen which also serves as a rest for the iron between soldering operations. Thus, the iron gets heat from two sources, internal and external. My iron heats much more quickly and keeps hotter under adverse conditions than it did with its original winding.

La Crosse, Wisconsin. VERNON W. PALEN.

Bending of Belts and Belt Life

IN THE SEPTEMBER issue of Power Plant Engineering, W. F. Schaphorst made a few statements about belts to which I cannot entirely agree.

He stated that the amount of belt bending in Fig. 1 was the same as that in Fig. 2. That is correct, but the belt in the instantaneous position as shown in Fig. 2, is "bent" more than that in Fig. 1. That is easily seen, since the included angle between the sections of the belt tangent to the idler pulley in Fig. 2, is much greater than that in Fig. 1. The diameters of the idler pulleys are equal.

Mr. Schaphorst also states that, "For pulling the load and from all other standpoints, Fig. 2 is preferable." This statement is incorrect from the standpoint of belt life. For belt life Fig. 2 is the worst possible condition, as I shall now prove.

Consider Figs. 3 and 4 which show the idler pulleys of Figs. 1 and 2, to a larger scale. Since pulleys A and B are equal in diameter, the elongation, or strain, of the outer fibers of both belts per inch of belt length

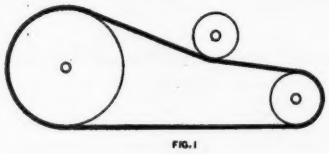


FIG. 1

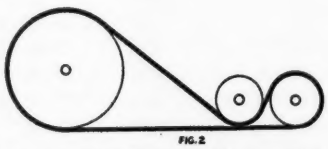


FIG. 2

Fig. 1. Idler used to take up slack
Fig. 2. Wrapper pulley used to increase arc of contact

on the pulleys, is the same. But this elongation in a given belt length, say XY, is absorbed by more free belt length in Fig. 3 than in Fig. 4. As a result, the outer fibers of the belt in Fig. 4 are stressed many times more than those in Fig. 3. Furthermore, these outer fibers have just previously been subjected to compression in going around the driving pulley. This

FIG. 3 FIG. 4

Fig. 3. Enlarged view of Fig. 1
Fig. 4. Enlarged view of Fig. 2

means that the real inside fibers of the belt are being submitted to compression and expansion alternately, or, in other words, a complete reversal of stress.

If these stresses were plotted against degrees of driving pulley rotation, the curve would be similar to that shown in Fig. 5.

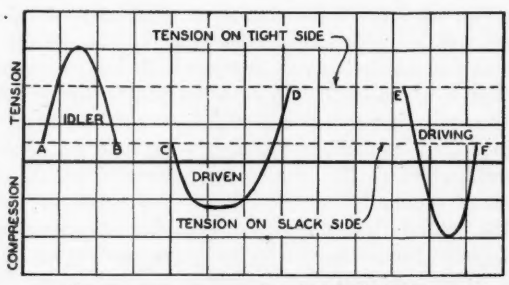


Fig. 5. Stress curve for inside belt fibers

The section of the curve from A to B represents the stresses set up in the inside fibers of the belt in passing around the idler pulley, showing that this stress

may go above that on the tight side of the belt. The sections of the curve from C to D and from E to F show the stresses set up in the inside fibers of the belt in passing around the driven and driving pulleys respectively. The sections of the curve, B to C, D to E, and F to A, show the stresses in passing from one pulley to the next.

It is this reversal in stress which causes friction between the fibers of the belt and ultimately results in ply separation and belt failure. It is the fact that the inside of the belt, which normally receives only compression, is subjected to tension that causes the damage. The more rapidly these reversals occur, and the greater the amplitude, the shorter is the life of the belt. Therefore, for long belt life, refrain from using idler pulleys such as is shown in Fig. 2.

Philadelphia, Pa. C. O. MITCHELL.

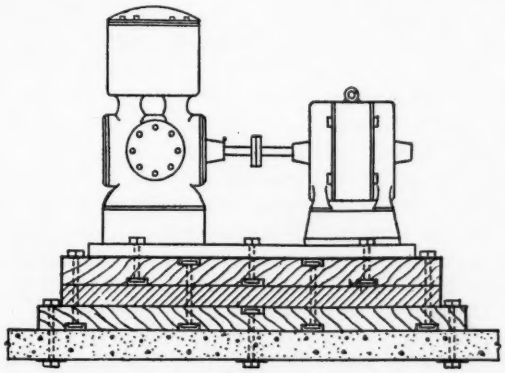


Fig. 1. Cork blanket under top of foundation

Vibrating Machinery in the Power Plant

THESE THREE sketches show clearly how to take care of power plant machinery that is likely to vibrate and cause noise nuisance. One of the most effective modern methods, as indicated in the sketches, is to isolate shaky machines from the building or from the ground by means of a strong resilient material. Natural cork is highly regarded. Cork has a natural period of vibration which is invariably different from that of any machine which fact is of great importance. Cork is elastic during a long period of years, which, too, is important. That is, cork does not gradually yield under pressure like most other materials. From many viewpoints natural cork is an ideal material for machine isolation. Sometimes the cork is placed directly under the machine on top of the foundation (Fig. 1), and at other times the foundation itself rests on the cork (Fig. 2), depending upon conditions. Thus Fig. 1 shows how to isolate an electrically driven unit, the unit being completely tied to a concrete slab in such a way that vibrations cannot be transmitted to the building, and yet the machine cannot jump off its base.

Figure 2 shows how to isolate a machine without secondary tieing bolts such as are shown in Fig. 1. In other words, the concrete base is here placed in a pocket lined with cork. This is usually a very satisfactory method of isolation.

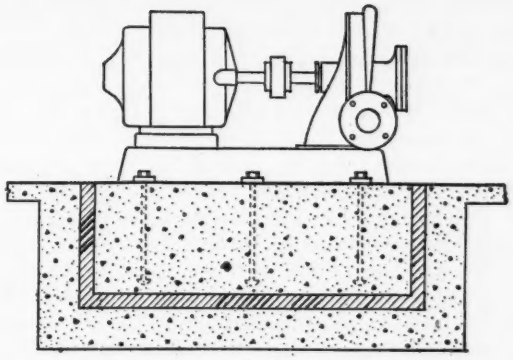


Fig. 2. Cork isolation for concrete base

Figure 3 shows in greater detail how the bolts may be isolated and applied. The rubber hose kink, for further isolating long through bolts, is a good one to remember. An objection to rubber is that it soon loses its elasticity, but for this purpose of merely surrounding a bolt that fault is of but little importance.

Through tieing bolts are important. Thus I have before me an erroneous design, the error being in the elimination of tieing bolts from a top slab of concrete to the lower slab. In other words, there is nothing to prevent the machine from bouncing around and dragging the top slab and the machine itself around on the floor. The designer may argue, "This

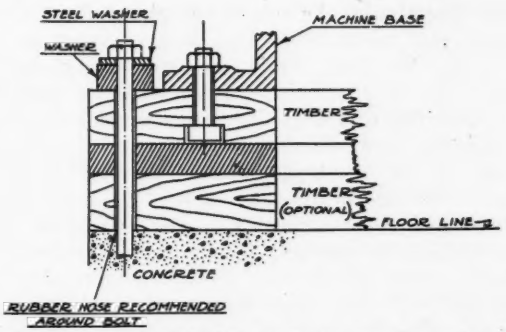


Fig. 3. Detail of method for isolating long through bolts

machine doesn't vibrate that much." To which a logical reply is: "If the machine doesn't vibrate that much it very likely doesn't need isolating. Why not be safe and use through bolts? They don't cost much more and are much to be preferred."

Newark, N. J. W. F. SCHAPHORST.

Duties of the Watch Engineer

THE LETTER of P. F. Rogers in the Readers Conference of the December issue of Power Plant Engineering, on the duties and responsibilities of a watch engineer, is worthy of further comment.

Not only should the retiring watch engineer report to his relief the condition of equipment, all changes or repairs that have been made during his watch and any further information that may be of value to the men coming on duty, but this practice should be carried out all along the line. Assistant and auxiliary

engineers, oilers, boiler room men and all others should make similar reports to their reliefs.

Recording charts should be observed at frequent intervals not only to see that clocks are running and ink flowing properly but also to note any deviation from the normal record. Any pressure, temperature or other change from the normal indicates an abnormal operating condition and should be investigated at once. When recorders are allowed to stop or run dry of ink they are useless as aids to the operating force and this practice should not be tolerated. In plants employing three shifts, the best time to change these charts is at midnight to avoid confusion in the calendar date and because there are usually better opportunities to do this. Charts should be prepared and dated by the previous watch and in small plants they can be put on by one man, but in the large plants this is impracticable. In a large plant it would take one man an hour or more to go from room to room to replace charts, so this work can be done more quickly and better by the operators that are located in each room.

In the statement that the watch engineer must be on hand when boilers or engines are put on or off the line, I presume that Mr. Rogers is speaking of plants where the watch engineer is the sole operating engineer. The operating responsibility belongs, of course, to the watch engineer, and in large plants he must be free to go to the scene of any trouble that may develop, and remain there until the trouble is disposed of, trusting in the judgment of his subordinates to carry on the operation of the rest of the plant. Most of the troubles that occur in turbine plants happen to the auxiliaries, so that, while the watch engineer is engaged in remedying the trouble in the auxiliary room, the operating engineer on the turbine floor will be obliged, because of lowered vacuum or other reasons, to use good judgment in having the loads adjusted on the turbines in service.

Most men react favorably to any additional trust or responsibility and the watch engineer should so train his crew that he can depend upon them at all times and rely upon them to exercise good judgment in trying situations. If he does this, his own labors will be lightened, his responsibilities will be shared by his men and will be to him a source of pride rather than one of worry.

Richmond Hill, N. Y. JOHN TOOKER.

Method of Applying Powdered Cork

I NOTE in the October issue of Power Plant Engineering that Mr. Schaphorst advises that when using cork insulation on cold water pipe have an expert apply it.

The following is a method of applying powdered cork, which is quite easy, and to which I am indebted to D. Sage, Superintendent of the Kearny (N. J.) Generating Station. First paint the surface to be insulated, and while this paint is wet throw the cork on by hand, collecting what falls off to be used over again. After a sufficient coating of cork has been thrown on the painted surface, the surface is given another coat of paint on the outside of the cork to restore the desired color.

I have tried this method and find it highly successful.

Wilmington, Del. FRANCIS M. NEWELL.

Boiler Rating Tables

RECENTLY there appeared in the Reader's Conference pages two articles the practical value of which I fail to see. One of these articles gave a method of procedure to be followed in filing a claim for shortage (real or supposed) on a car of oil. The other dealt with a plan for finding the horse power of boilers.

If one desires to check up on a tank car of oil to determine its actual contents in gallons, he should secure: an outage table from the shipper or from the car owner, which may be obtained gratis; a copy of Circular No. 154 of the Bureau of Standards; a thermometer and a hydrometer. The hydrometer may not be necessary if one is purchasing the same oil at all times and is sure he is getting what he specifies.

An outage table is needed as the so-called 8000 gal. tanks vary in capacity, so a graph or a curve for an 8036 gal. tank would not be quite accurate for one of a capacity of 8190 gal. Petroleum oil tables are needed as the temperature correction factor varies with the gravity of the oil. A correction of 1 per cent in volume for each 25 deg. F. the temperature of the oil is above or below the standard temperature of 60 deg. F. would be correct for an oil of a gravity of 22 deg. A.P.I. In abridged petroleum oil tables this factor is 0.0004 for each degree Fahrenheit change in the temperature of the oil is used for oil of a gravity up to 39.4 deg. F., although not exactly correct.

With this equipment a claim that will merit consideration may be filed with the shipper. In reading the gravity of the oil the temperature must be taken into consideration. This item with others of interest is explained in the oil tables.

Should one wish to know the horse power of a boiler, he should obtain free tables from the state boiler inspection department or from the Government Printing Office. These tables give the actual inside and outside diameters of tubes and flues, together with the square feet of heating surface of unit length of tubes and flues; the allowable heating surface of shells of standard dimensions; and other useful information.

With these tables, if one does not care to figure out constants of his own, it is only a question of a little addition and multiplication to determine the nominal horse power rating of a boiler. The codes of the various states correspond closely with the A.S.M.E. rating. It is well, however, to state what rating, as methods vary slightly in some states.

Tables of boiler ratings are distributed by the Department of Industrial Relations, Examiners of Steam Engineers, Columbus, O. Some of the Government Printing Office bulletins helpful in this connection are: Specifications for Flues, Industrial Series No. 63; Bureau of Mines Bulletins 114 and 240.

Sugar Grove, O. HENRY COONEY.

Refrigeration Nomograph

MR. CRANFORD'S interesting and instructive paper (Power Plant Engineering, p. 432, Sept. 1934) which deals with the calculation of the time required to freeze cakes of ice in commercial installations and with the determination of the number of cans to allow per ton of daily harvest, has prompted the construction of the accompanying nomograph.

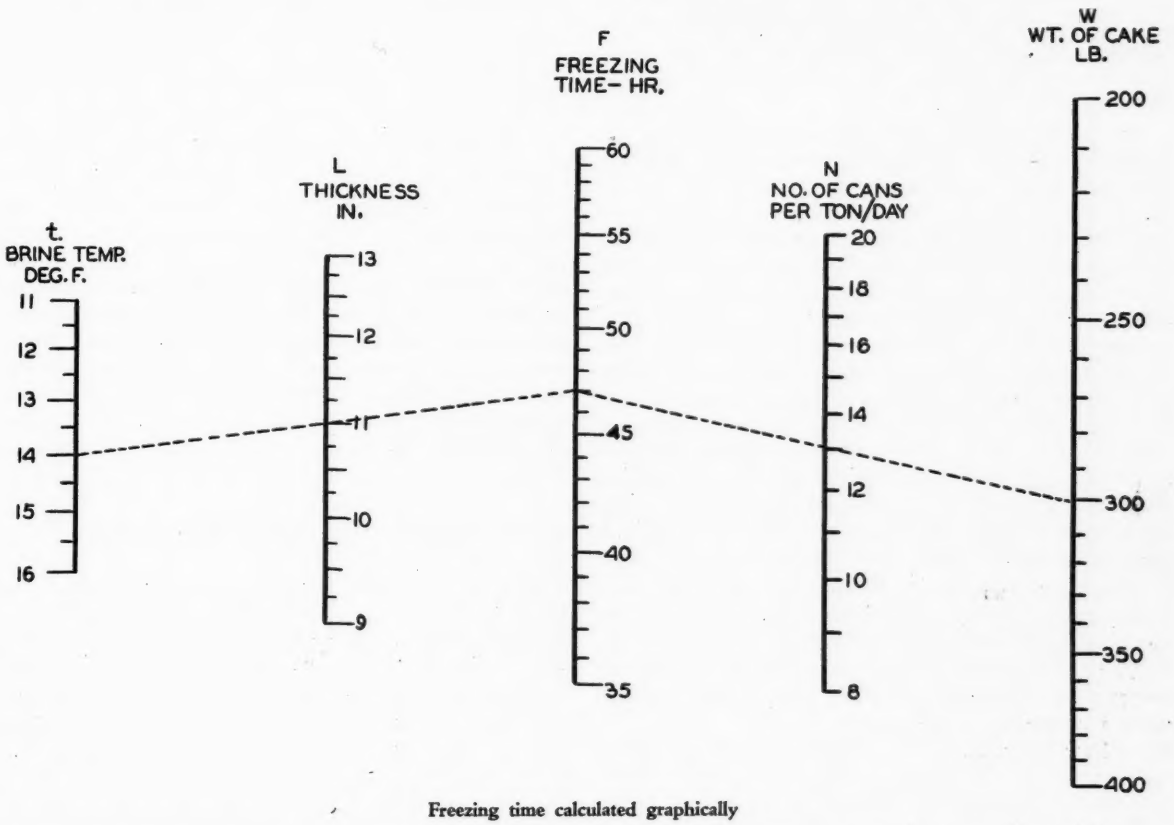
The alinement chart enables one to perform graphically the computations which Mr. Cranford has explained by the simple expedient of drawing two straight lines. The use of the nomograph may be illustrated by the following example in which Mr. Cranford's original values are employed. In the case of the standard installation making cakes of an average cross section of 11 by 22 in. how long will it take to freeze the cake if the brine temperature is 14 deg. F.? How many cans per ton of daily harvest will be needed if each cake weighs 300 lb.? Connect 14 on the temperature scale with 11 on the thickness scale and produce the line to the time scale where the intersection is at 47 hr. Connect this point with 300 on the weight scale and read the intersection with the N-scale as slightly over 13, showing that 14 cans should be provided for every ton of ice expected each day.

The chart solves the equations

$$F = \frac{7\,L^2}{32 - t} \quad \text{and} \quad N = 83.3\,\frac{F}{W}$$

where F = freezing time, in hours
L = average thickness of cake, in inches
t = temperature of the brine, °F.
N = number of cans per ton of daily harvest
W = weight of each cake, pounds.

Watertown, Mass. D. S. DAVIS.



Freezing time calculated graphically

Transformer Oil

WITH REFERENCE to W. E. Warner's discussion on Taking Samples of Transformer Oil in the Reader's Conference section of the November issue I would like to offer the following comments:

Contamination of transformer oil, during sampling, is a serious problem inasmuch as it is this pollution which affects the results of the tests conducted on the oil sample. The smallest percentage of water in the thief and sampling bottle lowers the dielectric strength of the oil and thus the test does not show the true condition of the transformer oil. The same holds true for contamination due to other impurities.

Incidentally, a thief is a glass tube which is used for taking samples from transformers not equipped with sampling valves or when samples of oil are required from both the top and bottom of the transformer. The sampling valve is usually located at the bottom.

Dielectric strength is still the criterion of the insulating properties of transformer oil, a high value indicating good insulation, a low value poor. Thus, it is obvious that contamination due to moisture is a serious matter when sampling.

It might be indicated, however, that in the last few years more and more consideration is being given to the acidity content and the color of transformer oils, these two factors having been found to be, in a degree, a measure of the sludging properties of the oil. The higher the acidity content and the darker the color usually is a positive indication that the oil will sludge when the transformer is operating at full load and subsequent high oil temperatures. This sludging eventually results in the clogging of the vent ducts and the coating of the insulation, causing hot spots and insulation deterioration.

In order that the thief and sampling bottles are absolutely free from contamination (and moisture free) one large utility company adopted the following cleaning practice. The dirty bottles are thoroughly scrubbed with a soap powder, no preference being given to any particular brand, then rinsed with city water to remove the suds. The clean bottles are then rinsed with distilled water and are hung mouth downwards in an oven. A mesh screen is provided to hold the bottles, and while they are drying the cork stoppers are thoroughly cleansed. They are also put into the oven. When dry they are dipped in paraffin and allowed to saturate. They are then pressed into the mouth of the now dry bottles and the protruding stopper and lip of the bottles paraffined thus sealing them from the atmosphere. They are then set in a moderately cool location until needed.

The same procedure is followed on the thief, even to the refinement of waxing the small cork stoppers and sealing the entrances after they are in place.

The above procedure has shown itself to be positive assurance against contamination and will be followed until a better one is found.

West New York, N. J. KERMIT B. HOFFMAN.

Use Steam Separators After Desuperheaters

WITH THE trend toward higher steam pressures and temperatures used in industrial power plants, it is often necessary to install desuperheaters. Among the principal applications of desuperheating equipment is the reduction in temperature of boiler steam after its passage through reducing valves. Steam, so reduced in pressure and temperature, is generally desirable for process or to supplement available low pressure exhaust or bled steam from prime movers.

In many cases, especially when a high pressure top is installed on an existing plant or when remodeling an old plant, economic considerations may dictate the retention of part or all of the original main or auxiliary prime moving equipment. These machines, unless redesigned for the new steam conditions, must generally be supplied with desuperheated or partially desuperheated steam.

When prime movers are supplied with steam from a desuperheater, a potential hazard from carryover of the water used for desuperheating always exists. Impurities from the evaporated water, if this water contains much solid matter, may also cause trouble. These hazards may be minimized if reasonable precautions are taken.

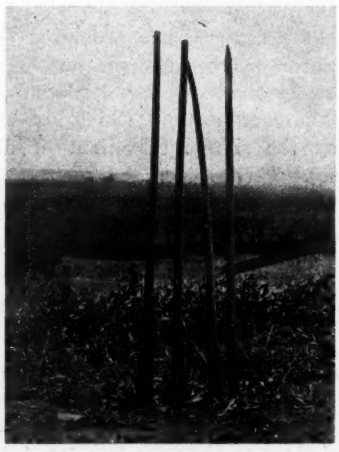
Under normal operating conditions the water separation devices built into modern desuperheaters show very high efficiencies. As a protection, however, against abnormal conditions resulting from failure of the water control equipment, or sudden increases in steam velocity, an efficient steam separator should be installed in the line between the desuperheater and the prime movers. Failure to provide a separator may result in severe damage to the moving equipment from erosion, or complete wreckage of the machines.

Care should be exercised when selecting a water supply for the desuperheater. It is the usual practice to supply desuperheaters operating at medium pressures with water from the boiler feed lines. As the percentage of raw water makeup in industrial boiler feed is usually high, scaling of the desuperheater parts or carryover of solids remaining after evaporation is often experienced. With water of this character it may become necessary to install separate pumping equipment to supply condensate or other pure water supply to the desuperheater.

Waynesboro, Va. S. H. COLEMAN.

"Stick 'Em Up" for Safety

"STICK 'EM UP", and the cool headed fellow generally does, as a matter of safety, particularly when confronted by a nervous holdup man. Industrial accident statistics, however, show a surprising number of accidents due to workmen accidentally stumbling or tripping over crow bars or lining bars left laying on the ground. The above photo shows obedience to



orders to 'stick 'em up' when not immediately in use, and was taken near construction work by a large power company. You can accidentally walk into a rigid upright bar and experience nothing but a minor bump, but tripping over one unnoticed or in the dark only too often starts one to the hospital.

Missouri Valley, Ia. FRANK BENTLEY.

Four 115,000 hp. Boulder Dam hydraulic turbines, 80,000 kw. Port Washington steam turbine and 2,000,000 v. high tension laboratory chief attraction to crowd of over 30,000

Allis-Chalmers Holds First Open House

ON SATURDAY, January 19, the Allis-Chalmers Mfg. Co., Milwaukee, Wis., held "Open House" and acted as host to over 30,000 interested visitors at its West Allis works. In the morning the employees, their families and their friends, and, in the afternoon the general public, entered into the holiday spirit of the event and took advantage of the occasion to become familiar with the activities of the company which plays such an important part in the lives of the inhabitants of Milwaukee and in the industrial activity of the nation.

From early morning until late in the afternoon, crowds swarmed over the works; through the pattern shops with its wood-making machinery and thousands of wooden and metal patterns; through the foundry with its cupolas, furnaces, moulding machines and facilities for making castings up to 120 t.; through the forge and machine shops with the large forging hammers and 40 t. boring mill; through the erection and assembly shops; through the testing shops and laboratory. Each unit as it was explained by willing and enthusiastic employees and by an excellent system of loud speakers, playing its part in forming definite opinions regarding the coöperative spirit and diversified interests of the company.

As explained in brief addresses by Otto H. Falk, chairman of the board, and Max W. Babb, president, the purpose of the gathering was to enable families and friends to become more familiar with the work and surroundings of the employees; to familiarize different departments with the organization as a whole; to acquaint Milwaukee and the surrounding countryside with the diversified products of the company; and to make it possible for engineers throughout the country to preview an unusual collection of large equipment in the course of manufacture.

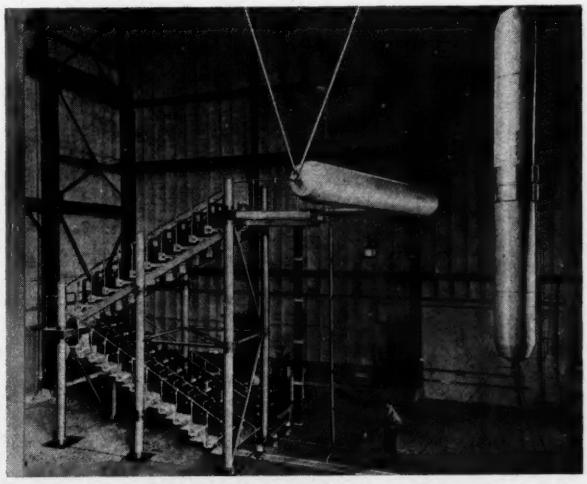


Fig. 1. The high tension laboratory where discharges from the 2,000,000 v. impulse generator added to the holiday spirit of the crowd

Representatives of the press were given a short summary of the activities and organization of the company by A. K. Birch, assistant to the general representative in charge of the publicity department. It is said that the diversification of equipment is greater than any other company in the world and includes machinery for the production of wheat from the soil to flour; tractors and farm machinery; crushing, mining and cement machinery; saw mill machinery; power machinery of all types including hydraulic and steam turbines, pumps, blowers, condensers, steam and gas engines, generators, transformers, electrical switching and control equipment, mercury arc rectifiers, motors, gears and transmission sheaves and feedwater treatment. In addition to the West Allis works the company now operates six branch plants, Norwood, O.; LaCrosse, Wis.; Springfield, Ill.; Pittsburgh, Pa.; Boston, Mass., and La Porte, Ind., the ground area of all shops totaling 493 acres.

For power engineers the highlights of the display were found in equipment soon to be shipped to the Boulder Dam plant of the Bureau of Reclamation, the Port Washington Station of the Milwaukee Electric Railway & Light Co., and State Line Station of the Chicago District Generating Co., although other well known names, the Ford Motor Co., Firestone Tire and Rubber Co., Colgate-Palmolive-Peet Co., Kosmos Portland Cement Co., Milwaukee Sewage Commission, Chicago Water Department, Chicago Sanitary District, Springfield Water & Light Department, Great Lakes Pipe Line and the Agua Fria Mining Co. were noticeable on shop tags attached to equipment in various stages of completion.

At the present time the company is building four of the largest hydraulic turbines ever built, 115,000-hp. units for Boulder Dam, each turbine designed for a normal flow of 2600 c.f.m. of water and to operate under a maximum head of 592 ft. Due to the large size and heavy weight of these turbines, the spiral

casings are made in six sections, ranging from 25 to 45 t. each. Several of these sections were on display in various parts of the shop in different stages of manufacture and test, giving an excellent demonstration of shop facilities and the method of construction. The main shaft of these machines is 38 in. in diameter and 26 ft. in length, made in two sections.

One of the turbines, completely assembled with the gates and operating cylinders, as shown by Fig. 2, was equipped with stairs and a walkway so that visitors could pass over and inspect the mechanism in operation. They were also able to walk in the 10 ft. diameter intake and through the spiral casing to the relief valve opening so as to see the interior construction.

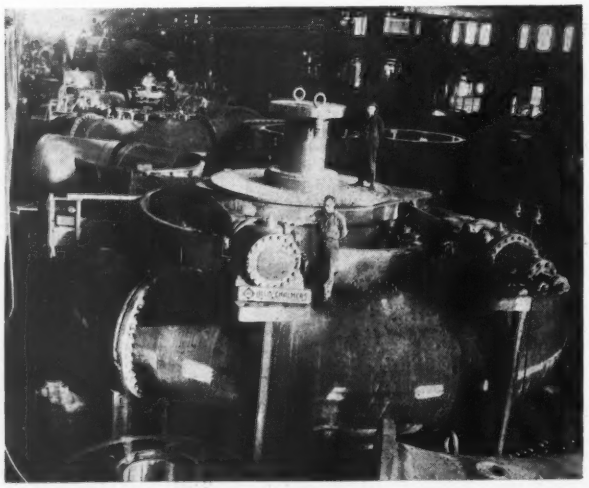


Fig. 2. Four 115,000 hp. turbines for Boulder Dam. Walkways over the top and through the casing of the first machine allowed visitors to closely inspect the gates and gate mechanism in operation

Much of the smaller electrical equipment for this same installation, bus structures, exciters, circuit breakers, etc., was on exhibition in the electrical shops, many of the pieces in actual operation. The extent to which welding is used in the design and construction of modern large machinery was pointed out and demonstrated very effectively by means of the welded generator stator frame for one of the 55,000 hp. Boulder Dam units.

As a contrast to the immense 115,000 hp. turbine, a 300 kw. self-contained water wheel, built sectionalized for aeroplane delivery, was shown. The complete unit takes up about the same space as one of the gate operating cylinders of the large units. The two machines, side by side, demonstrated very effectively the modern need for versatility in the engineering department and flexibility in the manufacturing plant.

Equipment for the Port Washington Station was also much in evidence in the steam turbine and electrical departments. The 80,000 kw., 1200 lb., 825 deg. F. reheat turbine shown by Fig. 3 complete with generators and exciters has an over-all length of about 96 ft. It captured much of the interest of the crowd because of the immense size and because the neighboring displays showed the various details of construction to advantage. The turbine has over 42,000 special alloy blades and the tip speed of the low pressure blades will be approximately 870 ft. per sec.

Many of the smaller turbines were exhibited, one of the most interesting being a 50 yr. old Parsons unit with a capacity of about 8 kw., intended to operate at 18,000 r.p.m. The evolution of steam and electrical machinery over a period of 50 yr. was evident not only from the relative size of the two units mentioned above but by the interior construction as shown by a near-by modern low pressure turbine spindle and by the rotor for one of the 125,000 kw. State Line generators. As with Boulder Dam, much of the electrical equipment, control panels, transformers, etc., for Port Washington was on display.

Smaller equipment, pumps, turbines, motors, blowers, Texrope drives, feed water treatment, etc., received their full share of attention, but the mercury arc rectifiers and Rannett pipe line pumps seemed to be of special interest to visiting engineers.

To the general public, however, the high tension electrical laboratory with its long sparks and cracking discharges appeared to be the center of interest. The impulse generator, one of the four largest in the world, develops 2,000,000 v. and was installed for the purpose of studying lightning effects on transformers and other electrical equipment. This generator, shown in Fig. 1, consists of capacitors arranged in 20 steps so that they may be charged with 100,000 v. d.c. by a rectifier.

After they have been charged, spark gaps are made to flash over and connect the 20 capacitors in series to develop the full 2,000,000 v. This discharge takes place rapidly, in the neighborhood of one micro second, and gives a heavy current.

It is of course impossible to even mention all the equipment shown which varied from the smallest Texrope sheave weighing a few ounces to large crushers which handle boulders as large as a small house. Nor is it possible to even list the shops in which the equipment was displayed. All that can be said is that the diversified line of equipment manufactured by the company, the shop facilities to handle these products and the spirit of friendliness and coöperation which pervades the organization was displayed to full advantage.

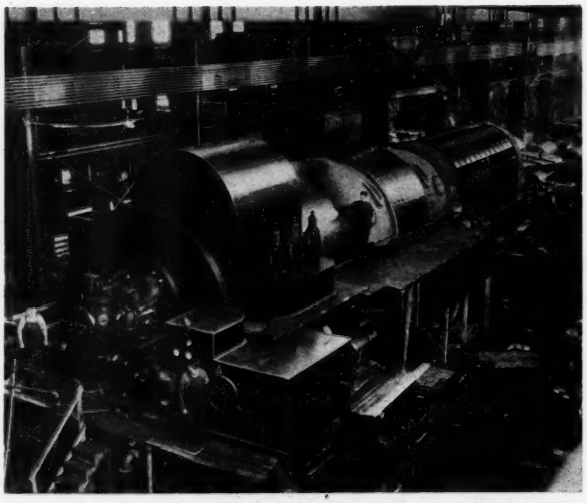


Fig. 3. The 80,000 kw., 1200 lb., 825 deg. F. reheat turbine for Port Washington Station

New Equipment

New Electric Flow Meter

THE Cochrane Corp., Philadelphia, Pa., announce a new electric flow meter a complete set-up of which, including orifice in pipe line, transmitter and recorder, is shown by the illustration. This meter using the null method is distinguished by the fact that the power for the operation of the pointer, pen and integrator is the same throughout the entire range of measurement. The pressure differential caused by flow through the orifice or nozzle is not required to move the registering mechanism. Instead this is done by external power from an electric motor, the application of this power being controlled by a sensitive relay.

Circuits and galvanometer are so proportioned that a displacement of the transmitter armature of less than 0.001 in. causes the galvanometer boom to deflect and is, therefore, registered by the recorder, corresponding in the usual installation to but 0.01 of one per cent change in rate of flow at midscale.

Accuracy is not influenced by variations in electrical resistance of conductors, by variations in contact resistance, by changes in length of leads, by inequalities in winding, by variations in strength of magnetic field, or the distance between receiver and transmitter. Variations in voltage and frequency, as ordinarily encountered in commercial practice, are immaterial. The consumption of current is not more than 25 watts.

As it is not always possible, prior to the installation of a flow meter, to predict the maximum and minimum rates of flow, seven interchangeable manometer tubes of different ranges are provided. The scale is uniformly graduated.

A calibrating rod is built into the transmitter to check the accuracy. Integration of the flow is performed at least once per minute, appropriate gear ratios being selected so that the integrator multiplier will be in integral terms for different meter capacities. The figures on the counting train read directly, just as do those of an automobile mileage recorder.

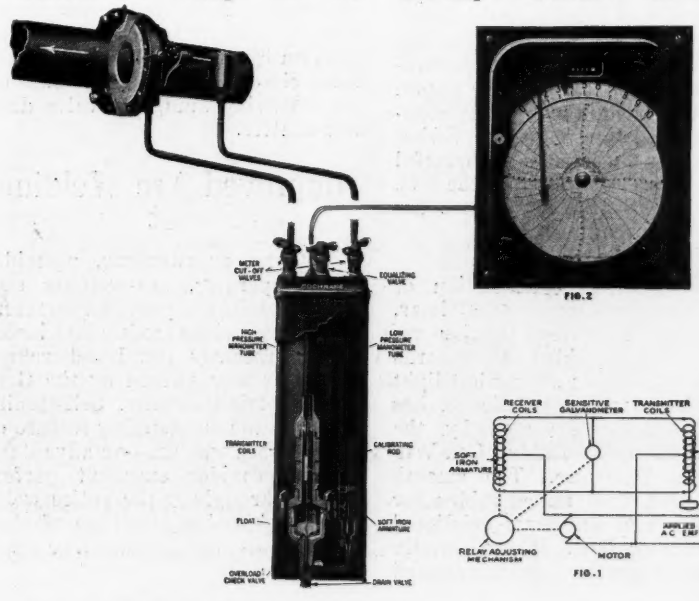


FIG. 2

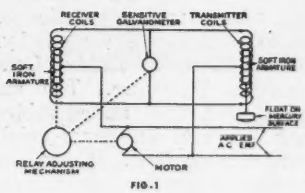
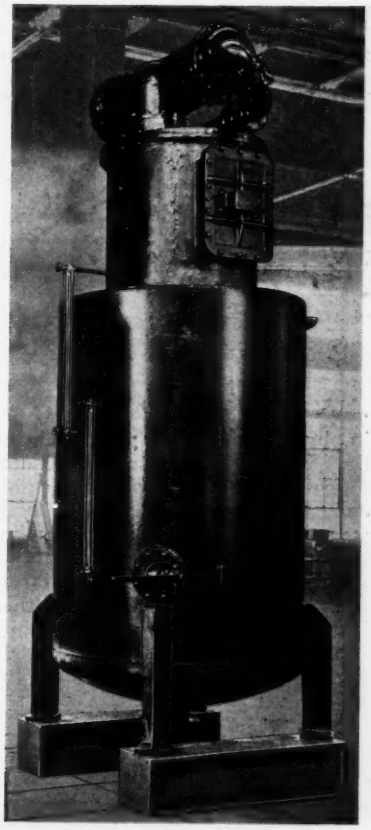


FIG. 1

Elliott Marine Type Deaerating Heater

THE ELLIOTT Co., Jeannette, Pa., has developed a special type deaerating heater for use in marine service, to remove dissolved gases from the feedwater so as to prevent corrosion in boilers, feedlines and steam lines, and to heat the feedwater exactly up to the saturated steam temperature. The two heaters shown are for installation on two large oil tankers, each heater having a capacity of 54,000 lb. per hr., being rigidly secured to the ship's structure. The deaerating element is of special design and construction to allow intimate contact of water and steam and uniform distribution of water, regardless of the roll and pitch of the ship.

Design is flexible so that the heaters can be fitted into the space available for installation on shipboard. Because of the headroom available on the oil tankers, the two heaters illustrated were built



along conventional lines with vent condenser on top and storage tank vertical. Heater heads are of non-storage type, made of cast iron in these heaters to give maximum resistance to corrosion, as this was considered more important than the extra weight over steel plate; but standard material for the shell and end heads is copper bearing steel or Armco ingot iron, as preferred, for the primary reason of minimum weight. Storage tanks are always of copper bearing steel or Armco ingot iron; vent con-

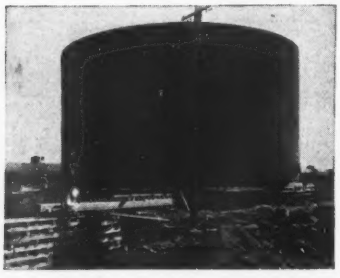
densers of steel plate or cast iron.

Water storage tanks may be vertical or horizontal to meet specific requirements for installation, and capacity of storage tank can be provided to meet the requirements of each application.

The design and construction of the equipment meets all requirements of the latest A.S.M.E. Code of Class 2, Unfired Welded Pressure Vessels, as well as the requirements of the American Bureau of Shipping and the U. S. Shipping Board.

Move 10,000 Bbl. Tank

THE UNUSUAL feat of raising a 100-t., 10,000 bbl. tank vertically 14 ft. from the ground level to an elevated railroad right of way and moving the unit intact 500 yd. has recently been accomplished in Chicago. The three year old cone-roof, bolted and welded tank (52 ft., 6

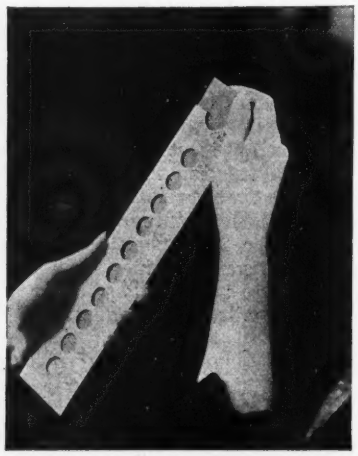


in. by 27 ft., 3 in.) was sold by the Hughes Oil Co. to the Seneca Petroleum Co. It contains eight compartments, one circular and seven radials, each equipped with steam coils which were left intact. Usual procedure is to cut a large tank apart to move it, but in this instance, because of the solid construction, this was not deemed necessary. The tank was built by the Graver Tank & Mfg. Corp.

Light-Sensitive Paper Indicates Lighting Intensity

THE WESTINGHOUSE Lamp Company has recently developed a simple device for determining lighting intensities. It is known as the Westinghouse Light-O-Graph and consists of a piece of extremely sensitive photographic paper enclosed in a light-proof envelope. The envelope is colored to a very definite shade and has ten round apertures through which the sensitive paper is exposed to the light. The sensitive paper, before exposed, is of a light yellow color. As it is exposed to light it turns darker. In 2½ min., under the proper lighting intensity, the sensitive paper will turn a shade as dark, or darker, than the color printed on the protecting envelope. If, however, in 2½ min. the sensitive paper is lighter than the protecting envelope, then the lighting is not of sufficient intensity.

With this new lighting indicator, anyone can determine in 2½ min. the condition of the lighting. The Light-O-Graphs may be used alone but are being distributed in conjuncton with a light analyzer



which affords the lighting user a further check on his illumination performance.

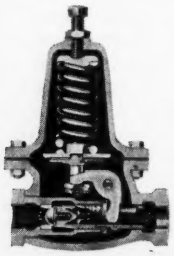
In the light analyzer, a pin is stuck vertically in the center of a circular disc. When placed on the desk, book, or counter, the pin throws a shadow, and discloses whether or not the light is coming from the proper direction. Shadowed areas on the disc tell the user which direction of light is correct.

If the light comes from the right, the light throws a disturbing shadow on the writing paper. From the front, the light is probably glaring into the eyes. Either situation is incorrect and harmful to the eyes. Coming from the left, the light properly illuminates the desk top or reading page.

NEW TYPE of construction of suction hose, known as Delmar, which has a woven tubular reenforcement of cabled cotton cords and wire, giving a strong but light hose which will not collapse, has recently been developed by the Electric Hose and Rubber Co., Wilmington, Delaware. The smooth lining is of compounded rubber for long life and minimum frictional resistance to flow. If accidentally crushed, it can be quickly restored to shape by use of a vise or mallet; it can be connected to standard couplings on the job, not requiring soft ends on the hose.

Streamlined Cash Reducing Valve

PRESSURE REDUCING valves in various trims, for all fluids, announced by A. W. Cash Co., Decatur, Ill., have streamlined features. Following airplane design, the valve proper has a blunt nose and a trailing edge, so that no matter how high the velocity, the trailing edge pulls no vacuum to retard flow, the purpose of this scientifically streamlined contour being to insure maximum capacity. The conventional dividing wall is



dispensed with; from inlet to outlet, the fluid flows through this valve without turbulence or hindrance to maximum flow.

A jet extends into the outlet chamber. When demand increases, an accelerated flow through this jet produces an aspirating effect that lowers the pressure in the control chamber (below diaphragm) and thus opens the valve wide to meet peak demand. When the diaphragm moves in a closing direction, the valve proper must close because it is tied to the diaphragm by means of the cam lever. As it closes against the pressure of the inflowing fluid, this valve does not chatter.

Improved Arc Welding Set

A LINE OF IMPROVED, portable, single-operator, arc-welding sets which retain the proved characteristics of previous models and incorporate recently developed refinements, is now offered by the General Electric Company. Self-stabilization is the outstanding feature of the new arc welders—an advantage which provides excellent performance throughout the entire welding range, using any type of electrodes, bare, lightly fluxed, or heavily coated.

The improved welders belong to what is designated as the WD-30 line. Each welder is a self-contained unit, having no external reactor, resistor, or separate exciter. It is largely due to the self-excited design of these machines that the inclusion of sufficient self-stabilization to provide steady welding characteristics under all conditions is possible. This self-stabilization makes the welding arc both "peppy" and stable at all times.

Separate controls are provided for adjustment of welding current and welding voltage. These controls are located on a dead-front panel on top of the machine and at the most convenient height above the floor. On this panel are also located a switch handle for reversing polarity and an instrument with selector switch for indicating welding current and welding voltage. All controls are clearly labelled to facilitate rapid and accurate adjustment.

Commutation is said to be excellent at all current values, and operating efficiency is high because of the lack of power-consuming accessories such as external reactors, resistors, and separate exciters.

All working parts of the machine are thoroughly protected against damage from water or other foreign materials by completely drip-proof construction.

The entire welding set is low-hung on a three-wheeled truck which provides unusual portability and mechanical stability, without sacrificing road clearance. The set may safely be tipped as much as 22 deg. from the vertical.

Five Speed Controller for Cranes and Hoists

FOR THE PURPOSE of giving greater flexibility in the handling of loads of widely different weights, The Shepard Niles Crane and Hoist Corporation has recently developed a Selective 5-speed push button controller for cranes and hoists.

The 5 speeds are controlled from one button. The operator,-increasing the pressure of his thumb, feels the change as each of the 5 independent speeds is obtained when the button is pressed or released. The first is a "creeping" speed. Each of the succeeding 4 speeds gives a gradual increase of torque. By releasing the button gradually the motor is slowed down through the same graduated speeds to a stop.

All 5 speeds are usually obtainable for lowering, regardless of the load. In hoisting, however, the percentage of rated load being lifted determines the number of speeds available. Thus, full loads will not move upward until the push button is pressed to the 3rd or 4th point.

It may happen that one speed point will give slightly insufficient torque to keep a load in motion and the next point will give a torque too high for very slow speed. In such cases, it is entirely practical to "jog" the push button between the two contacts. Jogging of this kind with the Shepard Selective Speed Controller involves no heavy arcing or mechanical

strains, and makes it possible to handle loads with practically any degree of care desirable.

Other features claimed for this controller include: — compactness and adaptability of mounting, similarity of construction and control features for both A.C. and D.C. They are built in 2 sizes—Class 1 and Class A rated at 3 hp. and 7½ hp., respectively.

New Reinforced Sheave

UNDER THE NAME of Duro-Brace Texsteel Sheave, the Texrope Division of the Allis-Chalmers Mfg. Co.,

is introducing a new reinforced steel sheave.

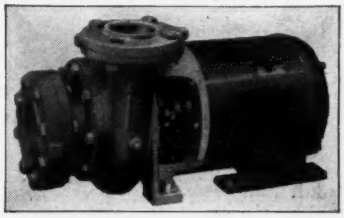
The outside walls of sheaves sometimes bend under the strain of excessive overloads, with the result that they are thrown off true. The outside walls of the new Duro-Brace sheaves are reinforced by a convex steel plate, which strengthens these vulnerable areas to so great a degree as practically to eliminate the possibility of distortion, irrespective of the strains to which they are subjected.

Welding at the rim and web, for additional strength, and the interior grid-type construction, for rigidity, which were advantageous features of the former design are retained in the new Duro-Brace Texsteel Sheave.

New Close-Coupled Centrifugal Pump

A COMPACT, close-coupled centrifugal pump of high efficiency with capacities ranging from 100 to 600 g.p.m. against heads up to 189 ft. was recently added to the line of pumps manufactured by the Chicago Pump Co., Chicago, Ill. This new pump is designed for circulating and cooling systems, standpipe and water supply systems and for transferring and handling all reasonably clear industrial liquids.

It is a single-edge, end-suction pump. The pump and motor are



built together as one unit with a single shaft. The enclosed type impeller is keyed to the motor shaft, which extends into the pump casing. There is only the one moving part.

The shaft is of one piece, large diameter, heat-treated steel with a bronze sleeve where it passes through the stuffing box. The impeller is of bronze, cast in one piece. Bronze wearing rings seal the impeller hubs against leakage. This pump is furnished either with or without a water seal.

There are two feet under the pump and four under the motor. The two feet under the pump support the weight of the pipes, thereby relieving the motor shaft and motor frame of any excessive stress or strain. This pump is also furnished mounted on a cast iron base, if desired.

Industrial Boiler Meter

BAILEY METER Co., Cleveland, Ohio, has developed a new steam flow-air flow boiler meter particularly well suited to industrial service.

This meter, illustrated here, records steam flow from the boiler, air flow supplied for combustion and flue gas temperature—all on one 12-in. diameter uniformly graduated chart. It also indicates steam flow on a porcelain enameled scale and integrates the total steam flow on a 6-digit counter which reads like an automobile mileage register.

Stoker Manufacturers Ass'n Elects Officers

J. R. WHITEHEAD, manager, stoker and research divisions, Fairbanks, Morse & Co., Chicago, was elected president of the Stoker Manufacturers Association at the annual meeting held in Cleveland, Ohio, on December 10. He succeeds W. H. Rea, president, Detroit Stoker Co., Detroit, who has served since the last annual meeting held in June, 1933. R. B. McClave, president, McClave-Brooks Co., Scranton, Pa., was elected vice-president, succeeding Mr. Whitehead. Harry H. Kurtz, Iron Fireman Manufacturing Co., Chicago, was re-elected treasurer and Marc G. Bluth, Chicago, was re-elected secretary.

Important problems facing the industry were thoroughly discussed in an all-day session and at the annual dinner in the evening the members listened to an interesting talk on "Fair Trade Practices" by W. C. Connolly, a prominent boiler manufacturer and a pioneer in the development of ethical trade practices in that industry. Other remarks were made by T. A. Marsh, Iron Fireman Manufacturing Co., and by the new and retiring presidents.

H. H. Kurtz was continued as the official representative of the Association on the Committee of Ten and the organization unanimously voted to contribute a substantial sum to help support the Committee's activities during 1935.

Midwest Engineering and Power Exposition

PLANS ARE being formulated for the 7th Midwest Engineering and Power Exposition to be held in Chicago during the week of Sept. 16, 1935. This exposition will cover the important fields of power generation, distribution and utilization and embrace the following classifications: Power generation —prime movers; electrical equipment — generators and motors; boiler room accessories and refractories; fuel burning; hydraulics, water softening, etc.; regulation and instruments; ventilating, cooling and heating; building and operation accessories; miscellaneous. Headquarters are at 1 North La Salle St., Chicago, Ill.

P. G. & E. Offers 50 per Cent Discount on Electricity

ELECTRICITY is 50 per cent off in northern and central California. The Pacific Gas & Electric Company offers this bargain to more than 450,000 homemakers and business men.

For one year beginning immediately after December meter readings there will be a 50 per cent discount on the amount by which the bills of residential and commercial lighting customers in any month exceed their bills for the corresponding month of the preceding year. For example, a consumer who used $3 worth of current last January may use $5 worth next January yet pay only $4 for it. In other words, he will get $2 worth of electricity for $1.

The idea is one of many worked out by the company to cooperate with the Federal Government's Better Housing Program. Under the low-cost loan plan set up by the National Housing Act, homeowners now can buy many additional electric appliances; under the Pacific Gas & Electric Company new special rate, they can operate such appliances for half the usual cost.

"This special rate", says Mr. P. M. Downing, vice-president and general manager of the Pacific Gas & Electric Company's, "is possible because there is a large surplus of power in northern California. We wish to give our residential and commercial consumers the benefits of this surplus —to enable them, at exceptionally low cost, to enjoy many more electrical conveniences and comforts.

"We expect the bargain to help business conditions. It should, for instance, result in greatly increased sales of electric appliances and fixtures.

"What's more, we hope that the offer will so stimulate increased use of current as ultimately to justify a reduction in the regular rate. For, as everyone knows, the price of electricity is largely determined by the extent to which it is used."

Milo S. Ketchum

ON DECEMBER 19, 1934, Milo S. Ketchum, Dean Emeritus of the College of Engineering of the University of Illinois, died at his home in Urbana. Dean Ketchum was born in 1872 at Burns, Ill. and received his bachelor degree in engineering at the University of Illinois in 1895. During his career he was contracting engineer for the American Bridge Co., dean of the University of Colorado College of Engineering, Administrative Director in the Government Powder Plant at Nitro, W. Va., and Professor of Civil Engineering at the University of Pennsylvania. He returned to the University of Illinois in 1922 as dean of the College of Engineering and director of the Engineering Experiment Station. He retired last year.

Wayne Rawley

WAYNE RAWLEY, vice-president and director of the Blaw-Knox Co., died Nov. 16 at Miami Beach, Fla., at the age of 56. Before his association with the Blaw-Knox Co., Mr. Rawley was with the Carnegie Steel Co., the Cambria Steel Co. and the Pencoyd Iron Works in an engineering capacity and from 1902 to 1913 with the Riter-Conley Mfg. Co. as manager of its Wood Run Plant. In 1912 he was elected vice-president of the Blaw-Knox Co.

News From the Field

LEONARD W. HORR, former Chicago Manager of the Henry Vogt Machine Co., Louisville, Kentucky, has become associated with the cooling equipment division of the Binks Manufacturing Co., Chicago.

JOHN WINTHROP HAMMOND, for the last 14 years a publicity writer for the General Electric Company, and a well known figure in electrical circles for his studies and writings of the pioneers of the industry, particularly of the late Charles P. Steinmetz, died at his home in Schenectady, N. Y., on December 27, following a brief illness. Mr. Hammond was born in Lynn, Mass., in 1887 and received his early education in Mount Vernon, N. Y. Except for personnel service during the World War, his life has been spent in the writing field, first in newspaper work and then for the General Electric Company, to which he came in 1920. Mr. Hammond was a profound student of electrical history, particularly of the inventions and advances made in and by the United States. Although his writings have portrayed the history of the industry itself and of many of its principal figures, such as Thomas Alva Edison, Charles A. Coffin, Edwin W. Rice, Jr., and Professor Elihu Thomson, Mr. Hammond was especially noted as the biographer of Dr. Charles P. Steinmetz. Mr. Hammond's "Charles Proteus Steinmetz—A Biography," published in 1924, and "A Magician of Science—The Boy's Life of Steinmetz," appearing in 1926, attest his unusual interest in the man who has been one of the greatest figures in the development of electrical science.

TEXAS TECHNOLOGICAL COLLEGE, Lubbock, Tex., will hold its first annual welding conference on electric and oxy-acetylene welding on February 14 and 15. In connection with the Conference, manufacturers are invited to display and demonstrate their equipment. The Conference will consist of lectures, accompanied by motion pictures and demonstrations on various phases of welding, and engineers interested in the subject are invited to sessions of the Conference which will be free of charge. Inquiries should be addressed to Professor H. F. Godeke, Texas Technological College, Lubbock, Texas.

ARMSTRONG PRODUCTS formerly sold by the Armstrong Cork Co. and the Armstrong Cork & Insulation Co. will be distributed by a subsidiary company to be known as "Armstrong Cork Products Co.," according to an announcement issued at the executive offices of the company in Lancaster, Penna. The change in the name of the sales organization does not in any way alter Armstrong's distribution policies or personnel and all corporate functions other than marketing will be continued under the name, Armstrong Cork Co., the announcement stated.

THE ERNEST E. LEE CO., with offices at 53 West Jackson Boulevard, Chicago, has recently been appointed by the Coppus Engineering Corp., Worcester, to handle the Coppus Air Filters for air compressors, internal combustion engines, industrial and ventilating applications.

THE APPOINTMENT of E. R. Jefferson of 332 South Warren Street, Syracuse, New York, as agent for all Babcock & Wilcox refractories provides representation for these products in the central and central-western sections of New York State.

HOWARD COONLEY, president of the Walworth Co., was reelected president of the American Standards Association for 1935. Mr. Coonley, who represents the American Society of Mechanical Engineers, has served two terms as president. Frederick E. Moskovics, representing the Society of Automotive Engineers, was reelected vice-president.

BEAVER PIPE TOOLS, INC., is the new corporate name to which The Borden Co. has been changed after 34 yr. in business. The new name identifies the company with the products it manufactures, which is a convenience to customers, and being distinctive will prevent confusion of names that have caused inconvenience in the past.

DIRECTORS OF BLAW-KNOX CO. recently elected Robert F. McCloskey director and vice-president in charge of operations of the plants located at Blawnox, Pa., to replace Wayne Rawley, deceased. Mr. McCloskey was previously general superintendent of the company's Blawnox shops. He has been associated with the company since 1920, starting as manager of a plant then located at Wheatland, Pa. In 1922 he was made production manager of shops at Blawnox, and in 1931 became general superintendent.

For the Engineer's Library

ELECTRICAL POWER METERING. By Archer E. Knowlton, First Edition, size 6 by 9 in. Cloth, 340 pages, illustrated. Published by McGraw-Hill Book Co., Inc., New York, 1934. Price $4.00.

The importance of the electric power meter is not generally appreciated until one stops to think of such meters in terms of the value of the power they measure. In this country alone the electric watthour meters last year measured over two billion dollars worth of electrical energy. Now, as the author of this book points out, superficially the technique of metering seems to be a simple routinized process, as prosaic as using yardsticks, quart measures or grocer's scales but actually, there is a wealth of underlying technology comparable in scope with that fundamental to generators, motors and electric circuit practice. A watthour meter is essentially a motor with highly refined characteristics; an instrument transformer is merely one of low kilowatt-ampere rating but designed to have better regulation than transformers in general.

It is because of the importance of metering and the complex theory underlying the design and operation of electric power meters, that this book by Mr. Knowlton should be of value to all who are in any way connected with metering practice. This book presents a treatment of the basic principles of energy and power metering, coupled with practical methods for kilowatt-hour reactive demand, telemetering, and totalizing applications. The terminology of the meter engineer is used, and clarifying discussions are given of obscure phenomena in instrument transformers, induction meters, unbalanced systems, incorrect connections, nonconcordant demand measurements, polyphase systems, etc.

The author, who is now associate editor of the "Electrical World," was formerly Associate Professor of Electrical Engineering at Yale University and Electrical Engineer of the Public Utilities Commission of Connecticut.

PHOTOELECTRIC CELLS. By N. R. Campbell and D. Ritchie. Published by Pitman Publishing Corp., 2 W. 45th St., New York City. Size 5½ by 8½ in. Cloth, 214 pp. Price $3.75.

Every day the field of application of the photoelectric cell is widening at an almost unbelievable rate. This growth has been accompanied by an equal amount of popular nonsense about the marvels of the electric eye which the authors feel has been a detriment rather than an advantage. Most applications fall in the group of simple detection where the function of the cell is to work a relay. The range of detection, sensitivity and means of application are now well understood and they feel that if in the design and advertisement of such applications less attention were paid to the photoelectric part and more to the remainder the ordinary engineer would soon regard the photoelectric cell as one of the normal tools of the trade.

The work is technical but simply presented and intended for those who desire to understand rather than merely follow the accepted practice. It is a practical handbook for the laboratory rather than for the practicing engineer. One cannot turn to the index and find a complete wiring diagram for "Job 2408" although he can get a comprehensive or concise discussion of the advantages, disadvantages and limitations of the various types of cells available.

Starting with the general theory of photoelectricity the emission, rectifier, and conductivity cells are treated in detail and with specific reference to their practical characteristics, sensitivity and time lag. The second part of the book deals with the use of the cells for detection, comparison and measurement, and the third part with application, discussing in particular, photometry and colorimetry.

BRITAINS EXPERIENCE with Unemployment Insurance is told in a 40-p. book'et published by the National Industrial Conference Board, Inc., of New York City. The study starts with the act of 1911 and covers to the act of 1934. Summarized, the lessons from British experience are given by the Board as follows:

(1) Unemployment insurance is not a remedy for depressional unemployment.

(2) Seasonal and casual unemployment tends to become permanent as a result of statutory unemployment relief.

(3) Chronic unemployment, due to permanent loss of trade, must be dealt with by other measures than unemployment insurance.

(4) Without an efficient and honest administrative force, unemployment insurance has no chance of success.

(5) Any scheme of unemployment insurance must be accompanied by a plan of unemployment relief for the workers who lose their right to insurance benefits or who cannot qualify for the receipt of benefit and for workers in uninsured occupations.

(6) If unemployment insurance is not supplemented by a scheme of relief, the temptation to extend statutory benefits to persons who are not qualified under the law is irresistible, making it impossible to avoid political raids on the unemployment fund until the state of national finances becomes so critical as to threaten the solvency of the nation.

(7) If unemployment insurance is uniformly applied to all types of unemployment, it impairs the elasticity of the economic system.

(8) If unemployment insurance is not based on an accurate knowledge of the facts of unemployment, it will be abused both by workers and by employers.

The Board's report points out that in the United States reliable information concerning the extent and nature of unemployment is almost totally lacking, and it suggests that before any compulsory scheme of unemployment relief is adopted it would be desirable to establish, under government auspices, a fact-finding body, composed of representatives of labor, industry, state and local governments, and the general public, to make a thorough survey of the facts of unemployment, its nature and extent, to hold hearings and to make recommendations for action by industry and by the legislatures. The results of such a survey should be of inestimable value in acquainting public opinion and the public representatives with the problems that arise in connection with an attempt to provide security against unemployment.

The price of the pamphlet is 50c.

TENTATIVE STANDARDS OF THE A.S.T.M. 1934. Published by the American Society for Testing Materials, 260 South Broad St., Philadelphia. Size 6 by 9 in., 1207 pages. Price $7 paper covered; $8 cloth bound.

This publication is issued each year and includes the tentative or proposed standards and revisions of earlier tentative standards of the society. This edition contains 236 tentative standards, 48 of which are included for the first time with some 60 revised this year and printed in their latest approved form to elicit criticisms before final adoption.

SPECIFICATIONS AND TESTS FOR COAL AND COKE. For the first time, a compilation of all the standard and tentative specifications and tests for coal and coke, as issued by the American Society for Testing Materials has been published, including 5 specifications, thirteen methods of test and the standard definitions of terms relating to coal and coke. Foundry coke and gas and coking coals are covered by specifications—and to make the pamphlet complete the recently approved requirements for classification of coal by rank and by grade developed by the Sectional Committee on Classification of Coals are included.

One of the important activities of A. S. T. M. Committee D-5 on Coal and Coke which is sponsor for the publication is the development of satisfactory sampling procedures. In this compilation are given the methods of laboratory sampling and analysis of coal and coke, and procedure for sampling coal; also sampling coke for analysis. The standard tests for the cubic foot weight of coke and of crushed bituminous coal are included, as well as the methods of sieve analysis of these products, and tests for the fineness of powdered coal. The shatter and tumbler tests for coke are detailed; also the method of determining volume of cell space of lump coke and testing for size of anthracite. An important test for the agglutinating value of coal, issued in the form of a proposed draft is given.

Copies of this publication aggregating 108 pages in heavy paper cover can be obtained from A. S. T. M., 260 South Broad Street, Philadelphia, at $1 each. On orders for ten or more copies special prices are in effect.

ONE OF THE MOST active projects of the A. S. T. M. Committee A-1 on Steel, is the development of standards covering materials for high temperature service. Tentative specifications for alloy steel castings and seamless alloy pipes for services from 750 to 1100 deg. F. have just been issued. Requirements for alloy-steel bolting, nuts and forgings are nearing completion. A proposed standard for carbon-steel nuts for steam service up to 850 deg. F. will be completed shortly.

A Section on High Temperature data proposes to compile creep data for available materials covering a range of temperatures from 750 to 1100 deg. F. which would fix their load carrying ability with reference to various rates of creep ranging from one per cent in 10,000 hr. to one per cent in 100,000 hr., the rate of creep being taken as that obtained over the period extending from the 700 hr. to the 1000 hr. of duration of the test.

TWO TENTATIVE SPECIFICATIONS of interest to the power plant field have recently been issued by the American Society for Testing Materials, 260 South Broad St., Philadelphia. One of these, designated as A 157—34 T, includes eight classes of materials for alloy-steel castings for valves, flanges and fittings, and the other, A 158—34 T, covers 12 alloys for seamless steel pipe.

REPUBLIC STEEL CORP. Massillon, O., is distributing a rotogravure tabloid containing 12 pages of illustrations of exhibits at the 1934 A Century of Progress Exposition in which Republic products were used and displayed.

INTERPRETATION of a Water Analysis is the title of a pamphlet recently issued by W. H. and L. D. Betz of Philadelphia, Pa., which contains a series of articles reprinted from issues of the Betz Indicator which have appeared in the past and they give a wealth of information of service to men in charge of water purification problems.

BROWN INSTRUMENT CO., Philadelphia, Pa., is making distribution of its catalog 2003 on Brown Flow Meters, containing 56-p. of details and data on performance with illustrations of installations.

D. W. HAERING & Co., Inc., Chicago, Illinois, announces the publication, at bimonthly intervals, of "H-O-H News" a house organ devoted to the presentation of news and personnel items in the scale and corrosion control and proportioning fields. Copies will be mailed to all those interested who write the company stating their business connnection.

WESTFALIA SEPARATOR CO., Bloomfield, N. J., has issued a series of five new catalogs covering its complete line of separators for both the dairy and industrial fields. Cream, yeast, starch, oil, soybean oil, and varnish separators are described and illustrated.

LEAFLET 2182, descriptive of the new Seal-Clad Induction Motor, with protected windings, has been issued by Allis-Chalmers Manufacturing Co., Milwaukee. This is descriptive of Seal-Clad Motors built in ratings up to 25 hp., 1800 r.p.m., furnished with either ball or sleeve bearings.

FLO-RATOR to indicate the rate of flow of any liquid having a variable viscosity is announced by Sterling Engine Co., Buffalo, N. Y., in a 6-p. pamphlet which gives method of application and prices. It was developed to aid economy in fuel oil combustion but is applicable to any heavy liquid such as varnish, paint, molasses and the like.

DRAFTROL GAGES for indicating and controlling draft, pressure or flow of gas or air are described in bulletin No. 2018 issued by The Hays Corp., Michigan City, Ind. These gages combine an indicating draft gage of the pointer type with a draft controller, and can be furnished with or without the indicating pointer or with one or two non-tilting mercury switches for either high or low voltage electric contact.

LINK-BELT CO.'s calender for 1935 is in attractive 12-p. form with current, past and coming months on each page. Headings illustrate the various products of the company and their uses for conveying, starting and power transmission.

DETAILS OF CLASS 3-AT air cushioned valve compressors with Timken roller bearings are covered in Bulletin No. 157 of the Pennsylvania Pump & Compressor Co., Easton, Pa. These are straight line machines built in cylinder sizes of from 4 by 4 in. to 26 by 13 in. with piston displacements of from 34 to 1987 c.f.m.

THE NEW YORK BELTING and Packing Company has just issued a new Mechanical Rubber Goods catalog, which provides practical information about hose, belting, packing, and miscellaneous mechanical rubber products. Illustrations and information are given about each product so that it can be applied to the best possible advantage. Diagramatic drawings show a clear outline of various applications. There are tables giving belt speeds, steam pressures and temperatures, carrying capacities, and dimensions. Numerous formulas on everyday problems are presented with practical examples of their usage.

"WHAT ABOUT YOUR ROOFS?" is the title of a new brochure just published by Johns-Manville. From a standpoint of protection to industrial and business buildings, the roof is the most vital part of the structure, and the new J-M booklet deals extensively with the important problems of construction and maintenance. Among the subjects discussed are included the importance of the "stitch-in-time" on roof repairs; the physical properties and characteristics of various types of built-up roofing materials; and the great importance of expert application and inspection during any roof construction job.

Considerable space also is devoted to a discussion of roof insulation and its effect in reducing fuel costs, in improving working or living conditions on upper floors, and in providing protection to both roof deck and roofing felts.

QUICK REFERENCE CHART has been developed which provides an easy and extremely simple method of designing expansion loops, using Tube-Turns and straight lengths of pipe or tubing, which enables the engineer, without going into involved calculations, to lay out quickly efficient, dependable loops that will meet almost any space requirement. Results given by the chart include an ample safety factor so that maximum fibre stress in loops will not exceed 16,000 lb. per square inch. Copies of this chart may be secured by writing Tube-Turns, Inc., Louisville, Kentucky.

THE FAIRBANKS CO., New York City, has just issued a new folder describing and illustrating its line of renewable gate valves. Included are list prices and dimensions.

THE FOURTH bulletin describing the Boulder Dam is now ready for distribution. As work progresses on the Boulder Dam, Ingersoll-Rand Company—manufacturers and suppliers of much of the air-compressing and rock-drilling equipment—has issued booklets covering the progress of the vast undertaking.

The present booklet (Volume 4) contains descriptions of the cofferdams; the aerial cableways; and the tunnels for the penstock headers, the penstocks, and the canyon wall outlets. It also tells of the method of pouring the concrete, and how the concrete is cooled while being poured.

Free copies of Volume 4 are available upon request at the company's main office, 11 Broadway, New York, or at any branch office.

MASTER WEIGHT TABLES for round steel tubing is the title of a booklet printed on standard letter size heavy paper, punched for standard three ring binders, issued by Timken Steel & Tube Co., Canton, O.

Weights per lineal foot of length are given for all sizes of hot drawn tubing of an outside diameter from 1/16 up to 10¾ in. and a wall thickness varying from 36 B.W.G. up to 1⅝ in., weights being given to four digits and outside diameters and wall thicknesses to three decimal places.

BOILER PLANT EQUIPMENT, covering coal and ash-handling systems is interestingly treated in a handsome 40-p. bulletin of the C. A. Bartlett & Snow Co., Cleveland, Ohio. The first few pages give a brief description of the development of Bartlett-Snow Centralized coal and ash-handling system. The advantages it offers are explained briefly, with tables to assist in determining the sizes and capacities of equipment required for various rated horsepower of plants. Typical plant layouts are suggested and diagrammed, with full and complete details as to track hoppers, weigh-type skip bucket loading gates, skip hoist buckets, skip hoist runways and head frames. Hoist engines and hourly capacities of skip buckets for various lengths of hauls are discussed. Advantages of cylindrical and suspension type coal bunkers are described, with a table in which are shown popular sizes of bunkers that can be furnished quickly from shop drawings. Weigh larries, including both hand-propelled and motor-driven types, are shown, also ash bunkers and facilities for ground storage of coal.

Blue print diagrams of layouts with dimensions and tables of sizes and capacities of equipment, together with views of arrangements and application make the book interesting and valuable for reference on its subject.

ELLIOTT CO., Pittsburgh, Pa., has issued a new descriptive bulletin on its type AY and BY mechanical drive turbines, improved types which were introduced a couple of years ago. The bulletin is illustrated with photographic views and sections through the turbine, overspeed governor, steam chest and speed governor.

THE MERIAM CO., Cleveland, Ohio, is issuing a series of informative post cards on the subject of gas engines. The first of the series deals with valve settings for natural gas operation. Subsequent mailing will cover lubrication problems, Meriam rebuilt gas and oil engines, etc.

THE MERIAM CO., Cleveland, Ohio, and Socony-Vacuum Oil Co., have jointly prepared a pamphlet containing operating instructions, oil and lubrication data, etc., for users of Meriam rebuilt gas engines. This information is designed to assist all gas engine users.

SPECIFICATION for Chrome-Manganese-Silicon Alloy Steel Boiler Plate has just been issued by Lukens Steel Co., Coatesville, Pa., covering the material Lukens Cromansil Steel. Copies can be had on request.

PROPOSED AMERICAN STANDARDS for pressure and vacuum Gages have been completed by Subcommittee No. 3 of the A.S.M.E. and is now being distributed for criticism and comment. Copies may be obtained from and communications should be addressed to C. B. LePage, Assistant Secretary, A.S.M.E., 29 West 39th St., New York City.

HYDROPRESS PUMPS, built by the Byron Jackson Pump Co., Berkeley, Calif., are described in a new bulletin No. 357. These are high-pressure, small diameter multistage centrifugal pumps, with capacities of from 10 to 200 gal. per min. for pressures up to 2,800 lb. per sq. in.

REFRIGERATING MACHINERY OIL for all types of machines and for all services is announced by the Frick Co., Waynesboro, Pa., in bulletin No. 140-A. Bulletin No. 154-B by the same company describes modern milk cooling cabinets and refrigerating units.

ELLIOTT CO., Pittsburgh, Pa., recently published a 32 p. bulletin, B-3, on Elliott engines and engine generator units. This bulletin describes and indicates the field for the single valve, four-valve, Corliss valve unaflow and poppet valve unaflow engines as built by the company.

TWO STAGE VOLUTE PUMPS, designated as type U, are described in bulletin W-317-B2 issued by the Worthington Pump and Machinery Corp., Harrison, New Jersey.

AN OPERATING MANUAL for plating with duozinc is the title of a recent 20 p. bulletin by the R. & H. Chemicals Department of the E. I. Du Pont De Nemours & Co., Inc., Wilmington, Del. Duozinc is a plating alloy of zinc with a small amount of mercury for use with cyanide solutions and used for protecting steel surfaces against atmospheric corrosion.

CALENDAR OF the Cooper-Bessemer Co., Mt. Vernon, Ohio, appears in attractive and convenient form, with current, preceding and following months on each sheet, the headpieces being views of various types of Cooper-Bessemer engines.

LINCOLN ELECTRIC CO., Cleveland, Ohio, sends a circular descriptive of its Shield-Arc welders of motor-generator type to run from two or three-phase standard current and deliver low-voltage, high-frequency current giving a more effective arc. Sizes, weights and dimensions are given.

CENTRIFUGAL PUMPS of the single stage volute, types L, LA and LC are covered by two bulletins W-312-B2A and B4 issued by the Worthington Pump and Machinery Corp., Harrison, N. J.

HARBISON-WALKER REFRACTORIES CO., Pittsburgh, Pa., has issued a folder entitled Insulate With Safety at Any Temperature, emphasizing the importance of the selection of the proper refractory as well as the proper insulating material for any insulated furnace construction and describing both insulating brick and light weight brick and their applications. The information covers diatomaceous earth brick for safe working temperature of 2000 deg. F., weighing approximately 1.75 lb. each; light weight brick of flint fire clay, approximately 2.8 lb. each, to withstand temperatures up to 2500 deg. F.; light weight silica brick, approximately 2.8 lb. each, for temperatures up to 2900 deg. F. The light weight brick are used as an insulating backing where the interface temperature between the refractory furnace lining and the insulation exceeds the safe working temperature of the usual type of insulating brick. They are also used as the refractory lining in furnaces where they will not be subjected to abrasion or to corrosive action of slags.

INTERNATIONAL SALT CO., Inc., Scranton, Pa., is distributing a highly useful 15-page booklet for the keeping of water softener records. The headings include date and time, meter readings, water softened (gal.), etc.

PYRO IMMERSION PYROMETERS for foundry use are described and illustrated in a new catalog issued by The Pyrometer Instrument Co., New York City.

THE PHILIP CAREY CO., Cincinnati, O., in a folder recently issued, lists its types of pipe covering, cements and packing, including data useful in calculating amounts needed for given areas.

INGERSOLL-RAND CO., New York City, in a bulletin recently issued, describes its new Pott Impact Wrench. This tool, working on a principle new to pneumatic tools, is capable of tightening nuts to any desired degree or of removing "frozen" nuts, each operation being performed by a separate wrench.

Power Plant Construction News

Ark., Pine Bluff—Arkansas Power & Light Co., Pine Bluff, plans extensive rural electrification program, including construction of transmission and distribution lines, with power substations and switching stations in group of 55 counties in state, totaling over 3000 miles of lines. Project will be carried out over period of months and is estimated to cost in excess of $5,000,000. Company engineering department will be in charge.

Calif., Fallbrook—Fallbrook Irrigation District plans electric power plant, using Diesel engine-generating units, in connection with extensions in irrigation system, using water from San Luis Rey River. Plant will be used for power supply for electric-operated pumping stations to be built, and other operating service. A transmission line will be constructed. Financing in amount of $1,100,000 is being arranged for project. Willis S. Jones, Claremont, Calif., is consulting engineer.

Calif., Fresno—Sante Fe Railroad Co., 560 South Main Street, Los Angeles, Calif., has approved plans for extensions and improvements in ice-manufacturing and precooling plant at Church and Railroad Avenues, Fresno. New refrigerating equipment will be installed. Entire project will cost about $225,000. Company engineering department is in charge.

Calif., Los Angeles—Wehle Brewing Co., West Haven, Conn., plans installation of power equipment in proposed new plant at Los Angeles, where site is being acquired. A boiler house will be built. Plant will be equipped for initial capacity of 150,000 barrels per annum, and will cost close to $100,000.

Ga., Atlanta—Sewell Hat Mfg. Co., care of Robert A. Sewell, 1732 Ponce De Leon Avenue, Atlanta, recently organized, plans installation of electric power equipment in new one-story plant, 60x200 ft., in Red Oak district. A boiler house will be built. Entire project will cost close to $45,000.

Ill., Chicago—Mills Novelty Co., 4110 West Fullerton Avenue, manufacturer of coin-operating machines, etc., plans installation of electric power equipment in new four-story plant, 62x200 ft., at 4036-54 Fullerton Avenue, for which building permit has been issued. Cost about $100,000. W. H. Farnum, 510 North Dearborn Street, Chicago, is architect.

Ind., Anderson—Greer Steel Co., Dover, Ohio, plans installation of electric power equipment in new cold rolled steel strip mill at Anderson, where large tract of land has been acquired. A power house is proposed. Work is scheduled to begin in the spring. Cost about $400,000. Company engineering department is in charge.

Ind., Elwood—Continental Can Co., 1 Pershing Square, New York, N. Y., plans installation of electric power equipment in new multi-story plant at Elwood, where site is being secured. A boiler house will be built. Entire project is estimated to cost close to $450,000.

Kan., Burlington—City Council has secured permission from Court to proceed with proposed municipal electric light and power plant, and plans will be completed at early date. Project will include an electrical distribution system. Fund of $145,000 has been arranged. E. T. Archer & Co., New England Building, Kansas City, Mo., are consulting engineers.

Ky., Louisville—Bonnie Brothers, 127 West Main Street, have approved plans for new one-story boiler house, 57x65 ft., at distillery on Thirty-fifth Street. Other additions will be built to distilling plant, with installation of power equipment for operating service. Entire project will cost close to $100,000. Thomas J. Nolan, Kentucky Home Life Building, is architect.

Md., Cumberland — Board of City Commissioners is making application to State Legislature for permission to arrange a bond issue of $1,500,000 for a new municipal electric light and power plant. Plans will be arranged at early date.

Md., Havre De Grace—Harford Pure Rye Distillers, Inc., Garrett Building, Baltimore, Md., plans installation of electric power equipment for distillery at Harve de Grace, where certain present buildings will be remodeled and new units erected. Cost over $85,000. Work begins soon.

Mich., Eaton Rapids—Horner Brothers Woolen Mills have authorized extensions and improvements in power house for mill service, including installation of additional equipment. Work will be carried out in connection with expansion program at mills, and will cost over $25,000.

Mich., Grand Rapids—Modern Brewing Co., plans installation of power equipment in new multi-story brewing plant. Cost about $100,000. Proposed to begin work at early date. George Fuchs is company architect.

Minn., New Ulm—Electric Light and Water Works Department, City Hall, plans installation of new ash-handling equipment at municipal electric light and power plant, and soon takes bids. Carl W. Franks, City Hall, city engineer, in charge.

Mo., St. Louis — Laclede Power & Light Co., 1017 Olive Street, will make additions in power plant at Mound and Wharf Streets, including extensions in electric generating and steam power departments. Work on latter will be placed under way first, to include installation of three new 1350 hp. boiler units and auxiliary equipment. Closely following, new addition will be built to generating station, with installation of two 15,000 kw. turbo-generators and accessories. Entire program will be carried out during 1935 and will cost over $1,500,000. Management & Engineering Corporation, 327 South La Salle Street, Chicago, is consulting engineer.

N. J., Woodbine — Borough Council plans new municipal electric light and power plant. Details and estimates of cost will soon be determined, and financing arranged. Nathaniel Rosenfeld, mayor, is active in project.

N. Y., New York—Treasury Department, Washington, D. C., plans central steam-operated electric generating plant at New York, for electric light and power service for group of 12 Federal buildings from Battery to Forty-second Street. Application has been made to PWA for appropriation of $3,780,000 for project, including transmission and distribution lines. Public Works Division, Treasury Department, will be in charge.

N. C., Charlotte—Hudson Silk Hosiery Co., plans installation of electric power equipment in new knitting mill in Oakhurst district, where large tract of land has been secured. A one-story boiler house will be built. Entire project will cost over $200,000. M. E. Pierson, president, is in charge.

Ohio, Troy—Gummed Products Co., Troy, manufacturer of gummed paper goods, plans new one-story boiler house at plant, in connection with expansion and improvement program at factory. Electric power equipment will be installed for general plant service. Entire program will cost close to $200,000. John H. Deekin, Times-Star Building, Cincinnati, Ohio, is architect.

Okla., Altus—J. A. McCurley, Ada, Okla., plans new one-story ice-manufacturing plant at North Lee and West Cypress Streets, Altus, estimated to cost close to $25,000, with equipment.

S. C., Creston—Broad River Power Co., Columbia, S. C., has authorized extensions in transmission lines from Cameron to Creston, with power substation facilities for distribution in latter district. Cost about $25,000. Company engineering department in charge.

Tenn., Chattanooga — Tennessee Electric Power Co., plans appropriation of about $1,300,000, for extensions and improvements in power plants and system during 1935, including transmission and distribution lines, power substations and other structures. New equipment will be installed in different plant units. Company engineering department is in charge.

Texas, Fort Sam Houston — Constructing Quartermaster, United States Army, plans steam power plant for central heating and operating service in new six-story hospital. Proposed to ask bids at early date. An appropriation of $1,933,000 has been arranged for structure and utilities.

Texas, Fort Worth — City Council plans new municipal electric light and power plant, and proposes to arrange for Federal aid in amount of $2,228,000 for project. Details of station will be arranged in near future.

Va., Richmond — Virginia Fruit Brandy Distilling Corporation, 721-29 Central National Bank Building, plans installation of electric power equipment in new plant in North Garden district. A boiler house will be built. Distillery will consist of several units and will cost over $85,000. P. Lester Hawks, Dixie Building, Greensboro, N. C., is engineer.

Wash., Walla Walla—Libby, McNeil & Libby, 3500 S. E. Thirty-second Street, Portland, Ore., food packers and canners, plans boiler plant in connection with new canning factory at Walla Walla, where site is being selected. New cannery will consist of several units; electric power equipment will be installed for operation. Entire project will cost in excess of $150,000. Company headquarters are at Union Stock Yards, Chicago, Ill.